Concept of Operations

for the Next Generation Air Transportation System

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Preface

The Joint Planning and Development Office (JPDO) is developing a Concept of Operations (ConOps) for the Next Generation Air Transportation System (NextGen). This version of the ConOps provides an overall, integrated view of NextGen operations in the 2025 timeframe, including key transformations from today's operations.

The development of the ConOps is an iterative and evolutionary process that encompasses the input and feedback of the aviation community. Version 3.0 of the document includes accepted comments resulting from an internal review and an expanded breadth of the NextGen concepts and capabilities. Details of the JPDO comment and review process can be found at www.jpdo.gov and progressing to the Joint Planning Environment (JPE).

This document serves as an interface to the NextGen Portfolio architectural, implementation, and business case elements contained in the Fiscal Year (FY) 2012 Enterprise Architecture (EA), Integrated Work Plan (IWP), and Portfolio Analysis which each reside in the JPE. Collectively the JPDO NextGen planning documents identify key research and policy issues that require resolution to achieve national goals for air transportation. In many cases, the ConOps presents "aggressive" concepts that have not been validated, but are envisioned to maximize benefits and flexibility for NextGen users. Many potential futures are possible, and much will depend on the insights gained by the evolution of the ConOps.

The research and policy issues pertaining to the capabilities described in the ConOps appear in detail in the IWP. Comments directed at refining these research and policy issues are requested during the IWP commenting process.

The following page outlines the ConOps development register.

Document Revision Register

Version	Document Content Added	Reviewer	Release Date
0.1	Initial document that includes the major “day-of-flight” air navigation elements that support operational activities of a flight moving from “block to block”	JPDO Staff and Integrated Product Teams	May 9, 2006
0.2	Major comments from Version 0.1 review	Aviation Stakeholder Community	July 24, 2006
1.0	Major comments from Version 0.2 review	Submitted to JPDO Board for Approval	Unreleased
1.1	Initial addition of remaining key NextGen concepts that support operations from “curb to curb” as well as planning and strategic support functions	JPDO Staff and Integrated Product Teams	November 14, 2006
1.1a	Revised Version 1.1, including air navigation and flight operation concepts as well as revised Executive Summary	JPDO Staff and Integrated Product Teams	December 6, 2006
1.1b	Major comments from Version 1.1/1.1a review	Integrated Product Team Leads	January 29, 2007
1.2	Major comments from Version 1.1/1.1a/1.1b review	Aviation Stakeholder Community	February 28, 2007
2.0	Major comments from Version 1.2 review	Submitted to JPDO Board for Approval	June 13, 2007
3.0	Incorporated NextGen Capabilities, Comments from Version 1.2 review, SSA and NCO ConOps	JPDO Staff and Working Groups	October 1, 2009

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The U.S. air transportation system as we know it is under significant stress. With demand in aircraft operations expected to grow significantly through the 2025 time frame, there are well-founded concerns that the current air transportation system will not be able to accommodate this growth. Antiquated systems are unable to process and provide flight information in real time, and current processes and procedures do not provide the flexibility needed to meet the growing demand. New security demands are affecting the ability to efficiently move people and cargo. In addition, the growth in air transportation has provoked community concerns over aircraft noise, air quality, and congestion. In order to meet the need for increased capacity and efficiency while maintaining safety, new technologies and processes must be implemented.

In response to these concerns, the Joint Planning and Development Office (JPDO) developed the Next Generation Air Transportation System (NextGen) Concept of Operations (ConOps). This document is not intended to describe the specific details needed for program implementation or planning; rather, the ConOps serves as a steering vision for the ultimate form of the NextGen end state of 2025. Its purpose is to provide an end-state vision (i.e., 2025 perspective of NextGen), or baseline, that forms a widely understandable summary of the goals, concepts, capabilities, and planned transformations needed to realize the NextGen vision. The goals for NextGen focus on significantly increasing the safety, security, and capacity of air transportation operations, thereby improving the overall economic well-being of the country.

These goals are achieved through a combination of new procedures and advances in the technology developed and deployed to manage passenger, air cargo, general aviation, and air traffic operations. The *Next Generation Air Transportation System's Integrated Plan* (2004) and *Vision Briefing* (2005) detailed the problems facing the National Airspace System (NAS) and identified eight key concepts needed to achieve the following goals:

- Network-enabled information access (net-centric operations)
- Performance-based services (now performance-based operations and services)
- Weather assimilated into decision making
- Layered, adaptive security
- Broad-area precision navigation (now positioning, navigation, and timing [PNT] services)
- Aircraft trajectory-based operations (TBO)
- Equivalent visual operations (EVO) (the characteristics of which are described throughout this concept)
- Super-density arrival/departure operations (now super density operations)

These transformational concepts are the driving factors for NextGen. Together, they include management of air traffic and airports to achieve greater safety and efficiency; security functions that will protect our airspace, people, and infrastructure; and the management of environmental impacts from aviation to improve the overall environmental quality. Vital to these changes is the need to leverage innovative technologies, such as satellite-based navigation and surveillance, to

create a scalable NAS that is able to support a two- to three-fold increase in air vehicle operations. Integrating security and national defense requirements into the NAS plan to enhance protection and ensure that aviation remains an economically viable industry in the decades ahead. Furthermore, the vision involves a system that is flexible enough to manage variations in demand, capacity, and aircraft fleet types; allows all communities to participate in the global marketplace; provides services tailored to individual customer needs and capabilities; and seamlessly integrates civil and military operations.

Building upon the NextGen concepts, the ConOps is organized around a set of NextGen Capabilities which detail the overall effect desired through the implementation of specific standards, processes and conditions. The NextGen capabilities create a top-down, architecturally based perspective, laying out a rationale, performance-based portfolio. Each capability is expressed in operational terms and can be implemented through various combinations of enabling solutions, such as policies, programs, and systems. With the NextGen capabilities, the JPDO has an effective planning framework to organize the significant collection of information in NextGen planning, which enables the JPDO to provide a coherent and compelling value proposition for the 2025 air transportation system. The set of nine NextGen capabilities allows the JPDO and NextGen stakeholders to communicate using common terminology and provide clear alignment between the NextGen investment portfolio and the resulting value to the stakeholders and the nation.

The nine NextGen capabilities defined by the JPDO are:

Provide Collaborative Capacity Management

Provide Collaborative Flow Contingency Management

Provide Efficient Trajectory Management

Provide Flexible Separation Management

Provide Integrated NextGen Information

Provide Air Transportation Security

Provide Improved Environmental Performance

Provide Improved Safety Operations

Provide Flexible Airport Facility and Ramp Operations

The NextGen capabilities emphasize system flexibility, scalability, robustness, and resiliency. They also stress the importance of distributed decision making, international coordination, increased user focus, and the provisioning of information to users while reducing the need for government intervention and resource control.

These capabilities fundamentally change the approach to air transportation operations in 2025. Capacity, flow management, and efficiency are increased with the transformation from clearance-based operations to TBO, as required by demand and complexity. Advancements in aircraft capabilities allow for reduced separation and support the transition from rules-based operations to performance-based operations. In addition, the transition of separation responsibility from the controller to the flight crew in some areas allows controllers to focus on overall flow management instead of individual flight management.

At the heart of the NextGen concept is the information sharing component known as net-centric operations (NCO). Its features allow NextGen to adapt to growing operations as well as shifts in demand, making NextGen a scalable system. NCO also provides the foundation for robust, efficient, secure, and timely transport of information to and from a broad community of users and individual subscribers. This results in a system that minimizes duplication, achieves integration, and facilitates the concepts of distributed decision making by ensuring that all decision elements have exactly the same information upon which to base a decision, independent of when or where the decision is made.

Shared Situational Awareness (SSA) services offer a suite of tools and information designed to provide NextGen participants with real-time aeronautical and geospatial information that is communicated and interpreted between machines without the need for human intervention. A reliable, common weather picture provides data and automatic updates to a wide range of users, aiding optimal air transportation decision making. PNT services reduce dependence on costly ground-based navigational aids by providing users with current location and any corrections, such as course, orientation, and speed necessary to achieve the desired destination. Real-time air situational awareness is provided by integrating cooperative and non-cooperative surveillance data from all air vehicles.

Security services are provided by a risk-informed security system that deploys on multiple technologies, policies, and procedures adaptively scaled and arranged to defeat a given threat. New technologies and procedures aid in passenger screening and checkpoint responsibilities. Baggage screening improvements include integrated chemical, biological, radiological, nuclear, and high-yield explosives detection and sensor fusion systems in a range of sizes for increased portability and remote screening.

Environmental interests are proactively addressed through the development and implementation of an integrated environmental management system. Technologies are incorporated before and during operations to enable optimized route selection, landing, and take-off procedures based on a range of data feeds including noise, air emission, fuel burn, and operational efficiency. At airports, a flexible, systematic approach is developed to identify and manage environmental resources that are critical to sustainable growth. Environmental considerations continue to be incorporated into aircraft design to proactively address issues, including noise reduction and aircraft engine emissions.

Aviation safety is steadily improved to accommodate the anticipated growth in air traffic while the number of accidents is decreased through an integrated safety management system. A national safety aviation policy will be established to formalize safety requirements for all NextGen participants. Safety improvement culture is encouraged by management and utilizes non-reprisal reporting systems. Safety assurance focuses on a holistic view of operators' processes and procedures rather than the individual pieces of the system. Modeling, simulation, data analysis, and data sharing are utilized in prognostic assessments to improve safety risk management.

Airports are the nexus of many of the NextGen transformation elements, including air traffic management (ATM), security, and environmental goals. Accordingly, the sustainability and advancement of the airport system is critical to the growth of the nation's air transportation system. Airports form a diverse system that serves many aviation operators and communities with different needs. New technology and procedures will improve access to airports, enabling better utilization of existing infrastructure and currently underutilized airports. The sustainability of existing airports will be enhanced with a preservation program to increase community support and protect against encroachment of incompatible land uses and impacts to airport protection surfaces. Finally, new airport infrastructure will be developed using a comprehensive planning architecture that integrates facility planning, finance, regional system planning, and environmental activities to enable a more efficient, flexible, and responsive system that is balanced with NextGen goals.

NextGen is a complex system with many public and private sector stakeholders that must smoothly, promptly, and capably integrate with the changes in the global air transportation system. National defense, homeland security, ATM, scheduled air transport and general aviation operators, and airports work together to support passenger, cargo, recreational, and military flights. Through a seamless and transparent information infrastructure and shared services environment, users gain a common picture of operational information necessary to perform required functions. Implementation of these highly integrated capabilities of NextGen will enable the means to meet the nation's demand for air travel in the most effective, efficient, safe, and secure manner possible.

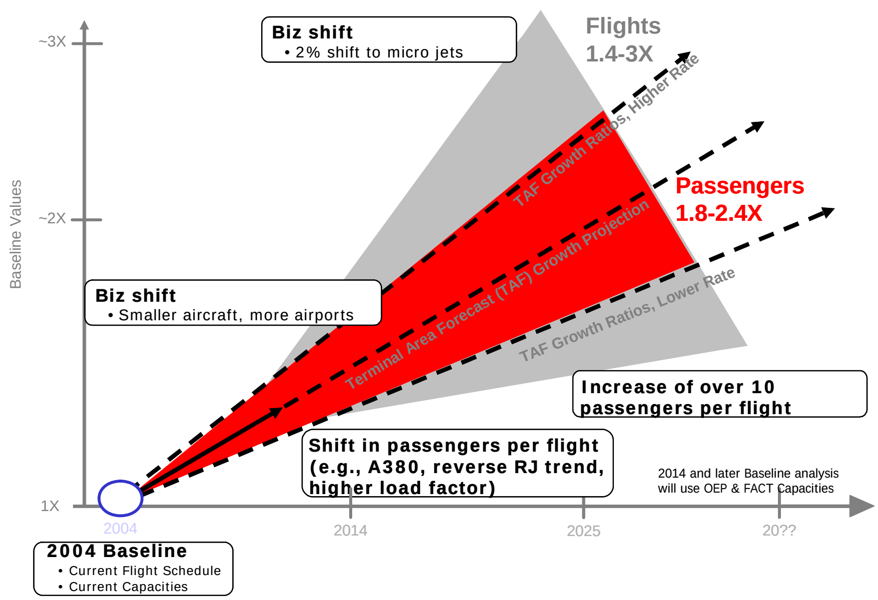
1 Introduction

The Next Generation Air Transportation System (NextGen) Concept of Operations (ConOps) describes the NextGen operational concept as envisioned in the 2025 time frame and provides a robust framework for the aviation stakeholder community to discuss the vision of improvements needed to achieve national and global goals for air transportation. The concepts and capabilities presented in this document provide an operational view of how air traffic and airports are managed, how security is provided to protect our airspace and people, how goals for protecting and enhancing our environment are achieved, and how processes in government and civil organizations provide increased safety and efficiency.

1.1 NEXTGEN ENVIRONMENT

In the NextGen time frame, demand for air transportation and other airspace services is expected to grow from today's levels in terms of passenger volume, amount of cargo shipped, and overall number of flights. With respect to air traffic, changes will occur not only in the number of flights but also in the characteristics of those flights. NextGen planning is intended to meet anticipated demand, in which Figure 1-1 illustrates some of the potential variations in demand characteristics. For example, a range in the potential increase of passengers exists. This range, combined with a potential range in the distribution of passengers to aircraft, may result in a wide range in the number of flights in NextGen; NextGen must be flexible enough to manage variations in number of passengers, types of aircraft flown, and overall number of flights.

Figure 1-1 Planning for a Range of Futures



Overall, NextGen is expected to accommodate significantly increased traffic levels with broader aircraft performance envelopes and more operators within the same airspace, increasing the

complexity and coordination requirements when air traffic management (ATM) is required. The NextGen concepts and capabilities described in Section 1.4 will be critical in meeting the NextGen goals.

1.2 BACKGROUND

The "Vision-100" legislation (Public Law 108-176) established a mandate for the design and deployment of an air transportation system to meet the nation's needs in 2025. The legislation also established the Joint Planning and Development Office (JPDO) to manage the public/private partnership and coordinate the transformative efforts required to carry out the NextGen mission.

The JPDO is a joint initiative of the Department of Transportation, Department of Defense, Department of Commerce, Department of Homeland Security, National Aeronautics and Space Administration, and the White House Office of Science and Technology Policy. In addition to these government agencies, the JPDO includes the NextGen Institute, which provides access to the knowledge, skills, and subject matter expertise of the private aviation stakeholder communities, enabling a two-way communication process between the government and the private sector.

> The U.S. aviation system must transform itself and be more responsive to the tremendous social, economic, political, and technological changes that are evolving worldwide. We are entering a critical era in air transportation, in which we must either find better, proactive ways to work together or suffer the consequences of … [losing] $30B annually due to people and products not reaching their destinations within the time periods we expect today.
>
> – *NGATS Integrated Plan*, 2004

In accordance with the requirements of the legislation, the Secretary of Transportation and the Federal Aviation Administration Administrator on December 12, 2004, delivered to Congress the *Next Generation Air Transportation System Integrated Plan (NGATS Integrated Plan)*, which set forth the National Vision for Air Transportation in 2025, and JPDO's approach to achieving air transportation system transformation. The vision emphasizes a shift in how information is accessed, allowing those who use the air transportation system to have more direct access to information affecting their operations.

The *NGATS Integrated Plan* clearly defines the problem: The U.S. air transportation system as we know it is under significant stress. With demand in aircraft operations expected to grow significantly through the 2025 time frame, there are well-founded concerns that the current air transportation system will not be able to accommodate this growth. Antiquated systems are unable to process and provide flight information in real time, and current processes and procedures do not provide the flexibility needed to meet growing demand. New security requirements are affecting the ability to efficiently move people and cargo. In addition, the growth in air transportation has elicited community concerns over aircraft noise, air quality, and congestion. In order to meet the need for increased capacity and efficiency while maintaining safety, new technologies and processes must be implemented.

The *NGATS Integrated Plan* recognizes these national needs and identifies six national and international goals and 19 objectives for NextGen. (Table 1-1.) Separately, each goal represents

an ambitious agenda. Meeting these goals and objectives requires a transformation that embraces new concepts, technologies, networks, policies, and business models.

Table 1-1 NextGen Goals and Objectives

Retain U.S. Leadership in Global Aviation	Expand Capacity
• Retain role as world leader in aviation • Reduce costs of aviation • Enable services tailored to traveler and shipper needs • Encourage performance-based, harmonized global standards for U.S. products and services	• Satisfy future growth in demand and operational diversity • Reduce transit time and increase predictability • Minimize impact of weather and other disruptions
Ensure Safety	**Protect the Environment**
• Maintain aviation's record as safest mode of transportation • Improve level of safety of U.S. air transportation system • Increase level of safety of worldwide air transportation system	• Reduce noise, emissions, and fuel consumption • Balance aviation's environmental impacts with other societal objectives
Ensure Our National Defense	**Secure the Nation**
• Provide for common defense while minimizing civilian constraints • Coordinate a national response to threats • Ensure global access to civilian airspace	• Mitigate new and varied threats • Ensure security efficiently serves demand • Tailor strategies to threats, balancing costs and privacy issues • Ensure traveler and shipper confidence in system security

The *NGATS Integrated Plan* lays out challenges facing the air transportation and the motivation for the air transportation system to grow and continue to serve the national and international community while responding to tremendous social, economic, political, environmental, and technological changes worldwide. During the next two decades, demand is expected to increase, creating a need for a system that (1) supports increased capacity, (2) is agile enough to accommodate a changing fleet that includes very light jets, unmanned aircraft systems (UAS), and space vehicles, (3) addresses security and national defense requirements, and (4) can ensure that aviation remains an economically viable industry.

1.2.1 Key Characteristics of NextGen

To meet the goals and objectives described in the previous section, the NextGen vision involves a transformed air transportation system that allows all communities to participate in the global marketplace by providing services tailored to individual customer needs and capabilities, and seamlessly integrating civil and military operations. The following paragraphs describe some of the significant NextGen characteristics.

1.2.1.1 User Focus

A major theme of NextGen is an emphasis on providing more flexibility and information to users while reducing the need for government intervention and control of resources. NextGen enables operational and market freedom through greater situational awareness and data accessibility, and it aligns government structures, processes, strategies, and business practices with customer needs. The provision of multiple service levels permits a wider range of tailored services to better meet individual user needs and investment choices.

With a focus on users, NextGen is also more agile in responding to user needs. Capacity is expanded to meet demand by investing in new infrastructure, shifting NextGen resources (e.g., airspace structures and other assets) to meet demand, implementing more efficient procedures (e.g., reducing separation between aircraft to safely increase airport throughput), and minimizing the effects of constraints such as weather on overall system capacity. The system will be nimble enough to adjust cost effectively to varying levels of demand, allowing more creative sharing of airspace capacity for law enforcement, military, scheduled air transport, and general aviation users. Restrictions on access to NextGen resources are limited in both extent and time duration to those required to address a safety or security need.

In NextGen, aircraft are expected to have a wider range of capabilities (e.g. improved avionics, airframes, and engines) than today and support varying levels of total system performance via onboard capabilities and associated crew training. Many aircraft will have the ability to perform airborne self-separation, spacing, and merging tasks and precisely navigate and execute four-dimensional trajectories (4DT). Along with navigation accuracy, aircraft will have varying levels of cooperative surveillance performance via transmission and receipt of cooperative surveillance information, as well as the ability to observe and share weather information. In terms of flight operational performance, a wider range of capabilities regarding cruise speed, cruise altitudes, turn rates, climb and descent rates, stall speeds, noise, and emissions will exist. Aircraft without an on-board pilot (e.g., UASs) will operate among traditional manned, piloted aircraft, and domestic supersonic cruise operations will also be more prevalent.

Aircraft operators are also expected to have a diverse range of abilities and operating modes. Many operators will have sophisticated flight planning and fleet planning capabilities to manage their operations. Operating modes include all of today’s modes, such as traditional hub/spoke operations, point-to-point flights, military/civil training, and recreational flying. Operational demand may vary among highly structured flights (e.g., today’s air carrier, cargo, or operators), irregularly scheduled flights with frequent trips to regular destinations with variable dates and times (e.g., air taxi operators or business operators with regular customers), and unscheduled, itinerant flights driven by individual events (e.g., lifeguard flights, personal trips, or law enforcement missions). In addition, new types of operations are expected, including UASs that perform a wide variety of missions (e.g., sensor platforms and cargo delivery) and more frequent commercial space vehicle operations (e.g., suborbital flights to low-earth-orbit payload delivery and return missions). Commercial space transport operations are also expected to grow overall, increasing pressures to efficiently balance competing needs for airspace access and efficiency.

1.2.1.2 Distributed Decision making

To the maximum extent possible, decisions in NextGen are made at the local level with an awareness of system-wide implications. This includes, to a greater extent than ever before, an increased level of decision making by the flight crew and flight operations centers (FOC). Stakeholder decisions are supported through access to a rich information exchange environment and a transformed collaborative decision-making process that allows wide access to information by all parties (whether airborne or on the ground) while recognizing privacy and security constraints. Information is timely, relevant, accurate, quality assured, and within established security procedures. Decision makers have the ability to request information when they need it, publish information as appropriate, and use subscription services to automatically receive desired information. This information environment enables more timely access to information and increased situational awareness while providing consistency of information among decision makers. Because decision makers have more information about relevant issues, decisions can be made more quickly, required lead times for implementation can be reduced, responses can be more specific, and solutions can be more flexible to change. To ensure that locally developed solutions do not conflict, decision makers are guided by NAS-wide objectives and test solutions to identify interference and conflicts with other initiatives.

1.2.1.3 Integrated Safety Management System (SMS)

NextGen ensures safety through use of an integrated safety management system (SMS) approach for identifying and managing potential problems in a system, organization, or operation. Specifically, NextGen uses a formal, top-down, businesslike approach to manage safety risk, which includes systematic procedures, practices, and policies for safety management, including:

- **Safety Policy.** Defines how the organization will manage safety as an integral part of its operations, and establishes SMS requirements, responsibilities, and accountabilities
- **Safety Risk Management (SRM).** The formal process within the SMS that consists of describing the system; identifying the hazards; and assessing, analyzing, and mitigating the risk. The SRM process is embedded in the processes used to provide the product or service—it is not a separate process.
- **Safety Assurance.** SMS process management functions that systematically ensure that organizational products or services meet or exceed safety requirements include the processes used to ensure safety, including audits, evaluations, and inspections, and data tracking and analysis
- **Safety Promotion.** Training, communication, and dissemination of safety information to strengthen the safety culture and support integration of the SMS into operations

1.2.1.4 International Harmonization

The ATM system is globally harmonized through collaborative development and implementation of identified best practices in both standards and procedures. International harmonization also requires advocating for the highest operational standards for aircraft operators and air navigation service providers (ANSP) to ensure the most secure and safest global air transportation system. International Civil Aviation Organization (ICAO) Planning and Implementation Regional

Groups or multilateral agreements coordinate planning and implementation of NextGen transformations to harmonize the application of technology and procedures. This harmonization allows airspace users to realize the maximum benefits of the NextGen transformations.

1.2.1.5 Taking Advantage of Human and Automation Capabilities

NextGen capitalizes on human and automation capabilities to increase airspace capacity, improve aviation safety, and enhance operational efficiency. This capitalization is based on building processes and systems that help humans do what they do best—choose alternatives and make decisions—and help automation functions accomplish what they do best—acquire, compile, monitor, evaluate, and exchange information. Research and analysis will determine the appropriate functional allocation of tasks among ANSPs, flight operators, and automation. They will determine when decision support tools are necessary to support humans (e.g., identifying conflicts and recommending solutions for pilot approval) and when functions should be completely automated without human intervention.

1.2.1.6 Weather Operations

In the NextGen environment, weather information is no longer viewed as separate data viewed on a "stand-alone" display. Instead, weather information is integrated with and supports NextGen decision-oriented automation and human decision-making processes. A common weather picture is used by all stakeholders. This common picture facilitates improved communications and information sharing. NextGen weather data is translated into information directly relevant to NextGen users and service providers, such as the likelihood of flight deviation, airspace permeability, and capacity. Flight trajectory plans are developed with an increased understanding of the potential severity and probability of weather hazards. As a result, less airspace is constrained because of weather. Operators of aircraft equipped with capabilities to mitigate the effects of weather may choose to tactically fly through certain weather-impacted areas.

Decision support systems (DSS) directly incorporate weather data and bypass the need for human interpretation, allowing decision makers to determine the best response to weather's potential operational effects (both tactical and strategic) and minimizing the level of traffic restrictions. This integration of weather information, combined with the use of probabilistic forecasts to address weather uncertainty and improved forecast accuracy, minimizes the effects of weather on NextGen operations.

1.2.1.7 Environmental Management Framework

Environmental management is performed in the context of the NextGen objectives. Capacity increases will be consistent with environmental protection goals to allow for sustained aviation growth. New technology, procedures, and policies in NextGen reduce in absolute terms compared to today's impacts on community noise and local air quality and mitigate water quality impacts, energy use, and climate effects. NextGen environmental compatibility is achieved through a combination of improvements in aircraft design, aircraft performance and operational procedures, land use around airports, and policies and incentives to accelerate technology introduction into the fleet. Intelligent flight planning and improved flight management capabilities enable the optimization of route selection, landing, and approach procedures based on a range of data, including noise, emissions, and fuel burn, thus enhancing the ability to reduce

environmental effects on the ground and in the airspace. Reinvigorated research and development (R&D) and refined technology implementation strategies—balancing near-term technology development and maturity needs with long-term cutting-edge research—help aircraft keep pace with changing environmental requirements.

1.2.1.8 Robustness and Resiliency

Overall, NextGen is more resilient in responding to failures and disruptions and includes contingency measures to provide maximum continuity of service, including business continuity in the face of major outages, natural disasters, security threats, or other unusual circumstances. Moreover, the increased reliance on automation is coupled with "fail-safe" modes that do not require full reliance on human cognition as a backup for automation failures. Because individual systems and system components can fail, NextGen maintains a balance of reliability, redundancy, and procedural backups. It provides a system that has high availability and also requires minimal time to restore failed functionality.

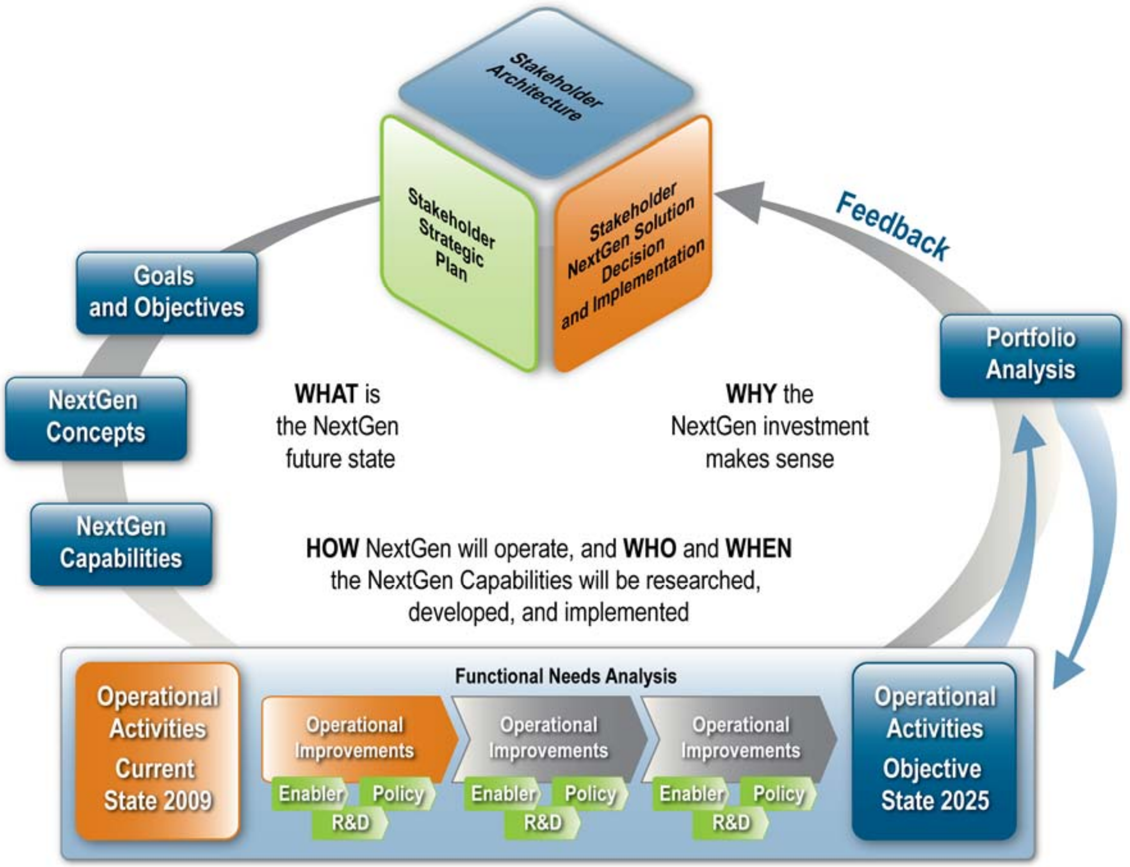
1.2.1.9 Scalability

NextGen is adaptable to meet the changes in traffic load and demand that occur every day or over the decades to come. Its capabilities provide an overall system design that can handle a wide range of operations and modes of operation. Increased use of automation, reduced separation standards, super-density arrival/departure operations, and additional runways allow busy airports to move a large number of aircraft through the terminal airspace during peak traffic periods. Each of these features contributes to an environment that supports growth in operations. New capabilities, such as Staffed NextGen Towers, enable the cost-effective expansion of services to a significantly larger number of airports than is possible with traditional methods of service delivery. As a result of its scalability, NextGen is able to adapt both up and down to changes in short-term or long-term demand, even when the changes are not predicted.

1.2.2 NextGen Planning Organization

To achieve the 2025 vision, goals, and objectives identified in the *NGATS Integrated Plan*, today's systems and processes must be rigorously and systematically transformed through the sustained, coordinated, and integrated efforts of many stakeholders. The NextGen goals identified in the National Plan will be achieved through the deployment of new operational concepts and capabilities as well as procedures and technologies to manage passenger, cargo, and aircraft operations. To support this endeavor, the JPDO has developed and will continue to refine key areas of NextGen planning: the ConOps, the Enterprise Architecture (EA), Integrated Work Plan (IWP), and the Portfolio Analysis. As identified in Figure 1-2, these planning areas describe "what" the NextGen end-state will be, "how" it will operate, "when" NextGen capabilities and improvements will be introduced, "who" will be responsible for implementing the capabilities and improvements, and "why" the investment is beneficial.

Figure 1-2 JPDO NextGen Planning



The intent of this ConOps is to describe a system that meets these national goals and to establish how to transform the air transportation system. Part of this transformation involves integrating and reshaping capabilities across all aspects of air transportation so that the entire system operates as an interconnected structure. In many cases, this operational concept builds on visionary material that captures the aviation community's goals for different aspects of transportation. For ATM, many of the concepts build on the *National Airspace System (NAS) Concept of Operations and Vision for the Future of Aviation* and the ICAO *Global ATM Operational Concept*, which represents a globally harmonized set of concepts for the future.[1]

A point of departure for NextGen is its scope. NextGen encompasses all aerospace transportation, not just aviation, and not just ATM. In addition to technological innovation, NextGen emphasizes changes in organizational structure, processes, strategies, policies, and business practice, including shifts in government and private sector roles that are required to fully exploit new technological solutions.

[1] RTCA, 2002

1.3 NEXTGEN STAKEHOLDERS

This document addresses aviation stakeholders and invites them to help develop the policy agenda, identify the research needed to achieve the NextGen operational concept and goals, and ensure global harmonization. Initially, JPDO will update this document periodically as research, implementation, models, policy, budget realities, and other findings are assessed and as further dialogue helps refine common goals and priorities. This document also serves as the official record and repository for operational concept insights that emerge from the in-progress national debate on the scope, characteristics, and capabilities of NextGen.

This ConOps is part of the overall NextGen enterprise architecture, and it will help formulate roadmaps and research recommendations to improve overall intergovernmental collaboration in achieving national goals for air transportation. This document, along with other engineering artifacts, also provides the basis for deriving top-level requirements.

The list of key NextGen stakeholders includes:

- **Airport Communities.** Cities and towns located in the vicinity of airports that have a vested interest in and are affected by the operation of the airport
- **Airport Operators.** Organizations and people responsible for enabling passenger, flight, and cargo operations conducted within an airport with consideration for safety, efficiency, resource limitations, and local environmental issues
- **Airport Tenants.** Organizations and people who offer services at an airport, such as fueling and maintenance services or catering services
- **ANSPs.** Organizations and people engaged in the provision of ATM and air traffic control services for flight operators for the purpose of safe and efficient flight operations. ATM responsibilities include communications, navigation, and surveillance (CNS); ATM facility planning, investment, and implementation; procedure development and training; and ongoing system operation and maintenance of seamless CNS/ATM services. This category includes ANSP personnel and ANSP automation.
- **Users.** Individuals and organizations, including government and military, using NextGen for personal or business transportation or to transport cargo
- **Flight Operators.** Individuals and organizations responsible for planning and operating a flight within NextGen, including flight crews (on the aircraft or controlling it remotely) and FOC personnel. Includes personal, business, scheduled air transport aviation, commercial organizations as well as government and military organizations.
- **Manufacturers.** Organizations and people who manufacture equipment for individuals such as flight operators, ANSPs, and security and defense providers. Includes the manufacture of airframes, aircraft engines, avionics, and other aircraft systems and parts as well as DSSs and other systems used in NextGen.

- **Resource Owners.** Organizations and people responsible for making investment decisions related to the development and implementation of NextGen and its associated capabilities
- **Regulatory Authorities.** Organizations and people responsible for certain aspects of the overall performance of the aviation industry, including aviation safety, environmental effects, and international trade. Includes aviation safety regulators, certification authorities, standardization organizations, environmental regulators, and accident/incident authorities
- **Researchers.** Organizations and people engaged in conducting Research and Development (R&D) activities that support the evolution of the air transportation system, including academia and government organizations
- **Security and Defense Providers.** Organizations and people responsible for national and homeland defense, homeland security, law enforcement, information security, and physical and operational security of NextGen
- **Weather Service Providers.** Organizations and people engaged in the provision of aviation weather information products

1.4 OVERVIEW OF NEXTGEN CONCEPTS AND CAPABILITIES

As previously described, this ConOps provides an overall, integrated view of NextGen operations in the “end-state” or 2025 time frame. The transformational concepts presented have not been validated, but are envisioned as potential initiatives to maximize benefits and flexibility for NextGen users and stakeholders. Many potential futures are possible, and much will depend on the insights gained by the evolution of the NextGen planning documents.

The NextGen goals significantly increase the safety, security, capacity, efficiency, and environmental compatibility of air transportation operations, and by doing so, improve the overall economic well-being of the country. These benefits can be achieved through a combination of new procedures and advances in the technology deployed to manage passenger, air cargo, and air traffic operations. The *NGATS Vision Briefing*[2] identifies the following concepts that will help achieve these goals:

- **Network-Enabled Information Access.** Through network-enabled information access, information is available, securable, and usable in real time for different communities of interest and air transportation domains. This greater accessibility enables greater distribution of decision making and improves the speed, efficiency, and quality of decisions and decision making. Information can be automatically provided to users with a known need and be available to users not previously identified as new needs arise. Information access improves operational decisions, enabling system operators and users to make use of risk management practices to enhance safety. Cooperative surveillance for civil aircraft operations, where aircraft constantly transmit their position, is used with a

[2] NGATS Vision Briefing, 2005.

separate sensor-based, non-cooperative surveillance system as part of an integrated federal surveillance approach.

- **Performance-Based Operations and Services.** Performance-based operations provide a foundational transformation of NextGen. Regulations and procedural requirements are described in performance terms rather than in terms of specific technology or equipment. The performance-based definition and delivery of services and levels of service will encourage private sector innovation and enable efficiencies throughout NextGen. Minimum performance levels are expected to be required to maximize capacity in congested airspace during specific periods of time. Service providers can use service tiers to create guarantees for different performance levels so that users can make the appropriate tradeoffs between investments and level of service desired to best meet their needs. A benefit of performance-based operations and services is that service providers can define capability improvements in terms of users' existing equipage, thus potentially maximizing the value of the service providers' and users' investments.

- **Weather Assimilated into Decision making.** By assimilating weather into decision making, weather information becomes an enabler for optimizing NextGen operations. Directly applying probabilistic weather information to ATM decision tools increases the effective use of weather information and minimizes the adverse effects of weather on operations.

- **Layered, Adaptive Security.** Through layered, adaptive security, the security system is constructed of "layers of defense" (including techniques, tools, sensors, processes, information, and a robust integrated risk management [IRM] system) that help reduce the overall risk of a threat reaching its objective while minimally affecting efficient operations. Layered security is additive; failures in any one component should not have a catastrophic effect on other components. For that reason, the system can handle attacks and incidents with minimal overall disruption. Layered, adaptive security adjusts the deployment of security assets in response to the changing IRM profile of risks; responses to anomalies and incidents are proportional to the assessed risk of involved individuals or cargo.

- **Positioning, Navigation, and Timing (PNT) Services.** PNT services are provided where and when needed, in accordance with demand and safety considerations, to enable reliable aircraft operations in nearly all conditions. Instead of being driven by the geographic location of a ground-based navigational aid, PNT services allow operators to define the desired flight path based on their own objectives.

- **Aircraft Trajectory-Based Operations (TBO).** The basis for TBO is each aircraft's expected flight profile and time information (such as departure and arrival times). The specificity of 4DT matches the mode of operations and the requirements of the airspace in which an aircraft operates. A major benefit of 4DT is that it enables service providers and operators to assess the effects of proposed trajectories and resource allocation plans, allowing service providers and operators to understand the implications of demand and identify where constraints need further mitigation.

- **Equivalent Visual Operations.** Improved information availability allows aircraft to conduct operations without regard for visibility or direct visual observation. For aircraft, this capability, in combination with PNT, enables increased accessibility, both on the airport surface and during arrival and departure operations. This capability also enables those providing services at airports (such as ATM or other ramp services) to provide services in all visibility conditions, leading to more predictable and efficient operations.

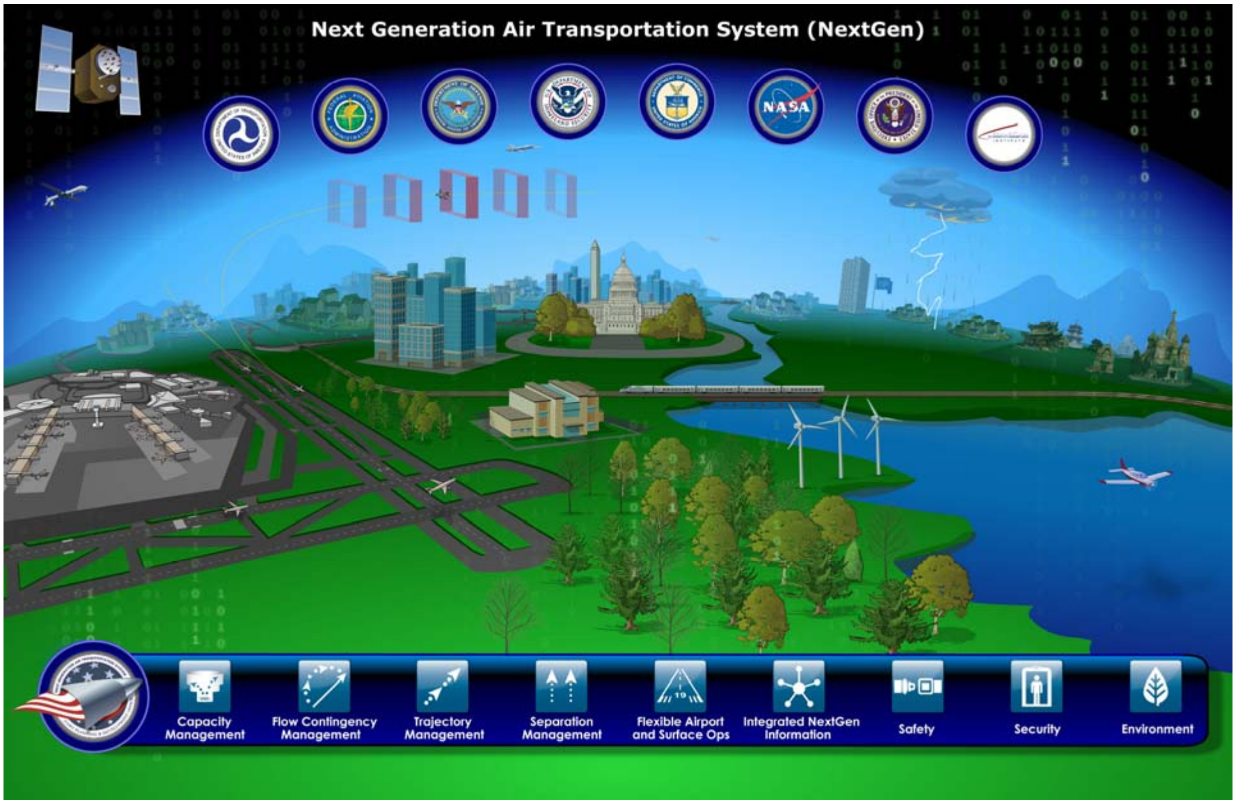
- **Super-Density Arrival/Departure Operations.** With increasing demand, an even greater need exists to achieve peak throughput performance at the busiest airports and in the busiest airspace. New procedures to improve airport surface movements, reduce spacing and separation requirements in place today, and better manage overall flows in and out of busy metropolitan airspace provide maximum use of the highest-demand airports. Airport terminals also maximize efficiency of egress and ingress, matching passenger and cargo flow to airside throughput while maintaining safety and security levels.

As previously described in Figure 1-2, these concepts have been further incorporated into the NextGen Capabilities (described further below), which are used as a common framework among the JPDO planning elements to describe, organize, and align the NextGen portfolio. These Capabilities are further woven throughout and incorporated into the framework of this document.

Figure 1-3 provides an overall operational view of the NextGen environment envisioned in 2025. The air transportation system is a complex global system with many public and private sector stakeholders. The system includes national defense, homeland security, ATM, scheduled air transport and general aviation operators, and commercial space transportation (CST) operators. It also includes airports that support passenger, cargo, recreational, and military flights, and spaceports (either dedicated or dual use) to support CST operations. NextGen integrates national defense and civilian functions to provide services to both civil and military users that are harmonized on a global scale. The integrated concepts of NextGen provide the capacity needed to meet the nation’s need for an air transportation system in the most effective, efficient, safe, and secure manner possible.

To help further describe the NextGen concept, a comprehensive set of capabilities have been identified to provide a framework for synthesizing and aligning the advanced concepts with the NextGen EA and IWP. The NextGen capabilities represent transformational improvements to the current air transportation system and can be achieved through various combinations of enabling solutions, such as policies, programs, and systems.

Figure 1-3 NextGen Community Model



The nine NextGen capabilities defined by the JPDO are:

Provide Collaborative Capacity Management: Collaborative capacity management provides the ability to dynamically balance anticipated/forecasted demand and utilization, and allocate NAS resources through proactive and collaborative strategic planning with enterprise stakeholders and automation (e.g., decision support systems), using airspace and airport design requirements, standards, and configuration conditions with the consideration of other air transportation system resources.

Provide Collaborative Flow Contingency Management: Flow contingency management provides optimal, synchronized, and safe strategic flow initiatives and ensures the efficient management of major flows of traffic while minimizing the impact on other operations in collaboration with enterprise stakeholders, through real- or near-real-time resolutions informed by probabilistic decision making within established capacity management plans.

Provide Efficient Trajectory Management: Efficient trajectory management provides the ability to assign trajectories that minimize the frequency and complexity of aircraft conflicts within the flow through the negotiation and adjustment of individual aircraft trajectories and/or sequences when required by resource constraints.

Provide Flexible Separation Management: Flexible separation management establishes and maintains safe separation minimums from other aircraft, vehicles, protected airspace, terrain, weather, etc., by predicting conflicts and identifying resolutions (e.g., course, speed, altitude, etc.) in real time, and accommodates increasing capacity demands and traffic levels by using automation (e.g., decision support systems) while also introducing reduced separation standards.

Provide Integrated NextGen Information: Integrated NextGen information provides authorized aviation stakeholders timely, accurate, and actionable information (e.g., weather, surveillance, aeronautical information, operational and planning information, and position, navigation and timing information) to shorten decision cycles and improve situational awareness using a net-centric environment managed through enterprise services that meets the information exchange requirements of the NextGen stakeholder community.

Provide Air Transportation Security: The capability to provide Air Transportation Security relies on the concept of layered, adaptive security based on risk assessment and risk management thus yielding the ability to identify, prioritize, and assess national defense and homeland security situations and appropriately adjust resources to facilitate the defeat of an evolving threat to critical NAS infrastructure and key resources using a collaborative approach (e.g., appropriate tactics, techniques, and procedures) without unduly limiting mobility, making unwarranted intrusions on civil liberties, and minimizing impacts to airline operations or aviation economics.

Provide Improved Environmental Performance: Improved Environmental Performance ensures environmental management considerations, including flexibility in identifying, preventing, and proactively addressing environmental impacts, are fully integrated throughout the air transportation system decision-making process, through increased collaboration and improved tools, technologies, operational policies, procedures, and practices that are consistent and compatible with national and international regulations.

Provide Improved Safety Operations: Improved safety operations ensure safety considerations are fully integrated throughout the air transportation system through increased collaboration and information sharing, improved automation (e.g. decision support systems), prognostic safety risk analysis, and enhanced safety promotion and assurance techniques that are consistent and compatible with national and international regulations, standards, and procedures.

Provide Flexible Airport Facility and Ramp Operations: Flexible airport facility and ramp operations provides the ability to reallocate or reconfigure the airport facility and ramp assets to maintain acceptable levels of service that will accommodate increasing passenger and cargo demand levels, or changes in operational requirements, through infrastructure development, predictive analyses, and improvements to technology (e.g., automation and decision support systems) and procedures.

With the NextGen capabilities, the JPDO has an effective joint planning framework to organize the significant collection of information in NextGen planning documents and provide a coherent and compelling value proposition for the 2025 air transportation system. The NextGen capabilities also allow the JPDO and NextGen stakeholders to communicate using common terminology and provide clear alignment between the NextGen investment portfolio and the resulting value to the stakeholders and the Nation.

1.5 DOCUMENT SCOPE AND ORGANIZATION

This document describes the operational concepts for NextGen in the 2025 time frame. It is organized into the following chapters. The implementation, research, and policy issues fundamental to the information contained in this document are available at www.jpdo.gov within the Joint Planning Environment (JPE).

- **Chapter 2.** Provides a description of **Air Traffic Management Operations** within NextGen, including interactions among ANSPs and operators
- **Chapter 3.** Provides a detailed overview of the **Airport Operations and Infrastructure Services** that address the activities surrounding the airport
- **Chapter 4.** Addresses **Net-Centric Operations** that enable the NextGen enterprise services
- **Chapter 5.** Provides an initial overview of specific **Shared Situational Awareness Services** that support the ATM-related NextGen concepts
- **Chapter 6.** Provides a detailed perspective of **Layered, Adaptive Security Services** within NextGen
- **Chapter 7.** Describes how environmental impacts will be addressed and reduced in an **Environmental Management Framework** for NextGen

- **Chapter 8.** Addresses the **Safety Management Services** woven into NextGen, including risk management efforts

Included in the document are the following appendices, which contain supplemental information for the reader:

- **Appendix A.** Provides a list of acronyms used in this document
- **Appendix B**. Provides a glossary of terms

Additional information on the glossary of terms and acronyms is located within the NAS/JPDO Enterprise Architectures Controlled Vocabulary contained within the JPDO JPE, in addition to supplemental information for the reader for all of the JPDO Products.

2 Air Traffic Management Operations

2.1 INTRODUCTION

Air Traffic Management (ATM) is the dynamic, integrated management of air traffic and airspace—safely, economically, and efficiently—through the cost-effective provision of facilities and seamless services performed in collaboration with all parties. In the Next Generation Air Transportation System (NextGen) time frame, ATM evolves into an agile, robust, and responsive set of operations that can keep pace with the growing needs of an increasingly complex and diverse mix of air transportation system users. As previously described in Chapter 1, the three major goals, as described in the NGATS Integrated Plan, for ATM in NextGen are:

- Meet the diverse operational objectives of all airspace users and accommodate a broader range of aircraft capabilities and performance characteristics
- Meet the needs of flight operators and other NextGen stakeholders for access, efficiency, and predictability in executing their operations and missions
- Be fundamentally safe, secure, environmentally acceptable, affordable, and of sufficient capacity for both flight operators and service providers

Today's ATM system performs well, but it is susceptible to disturbances, such as weather events, and is reaching its capacity limits. The NextGen ATM system needs to be *scalable* enough to respond quickly and efficiently to increases in demand and *flexible* enough to respond to changes in fleet mix, customer schedules, and operational constraints (e.g., weather).

The overall philosophy driving the delivery of ATM services in NextGen is to achieve a flexible system that accommodates flight operator performance optimization when and where possible while minimizing imposed restrictions by applying them only when user actions are not sufficient to balance demand and capacity. This philosophy also includes the need to meet capacity, safety, security, and environmental constraints. In other words, the ATM system, to the maximum extent possible, adjusts airspace and other assets to satisfy forecast demand, rather than constraining demand to match available assets.

Transformation of the ATM system in NextGen is necessary because of the inherent limitations of today's system, including limits driven by human cognitive processes and verbal communications. Safety, capacity, security, and environmental requirements are integrated into all aspects of the ATM system, including operations, decision support, automation, procedures, and airspace design.

To achieve the three major goals for ATM in NextGen, a number of NextGen Capabilities and changes in operations and services, which will change roles and responsibilities are needed to fundamentally change how ATM is performed in the NextGen time frame (see NextGen

Capabilities listed below and Figure 2-1 respectively). To assist in further achieving NextGen ATM goals and describing the NextGen ATM concepts, a set of capabilities has been identified to provide a framework for organizing the NextGen portfolio. These NextGen capabilities represent transformational improvements to the current air transportation system and can be achieved through various combinations of enabling solutions, such as policies, programs, and systems.

The four ATM Capabilities are:

Provide Collaborative Capacity Management: Collaborative capacity management provides the ability to dynamically balance anticipated/forecasted demand and utilization, and allocate NAS resources through proactive and collaborative strategic planning with enterprise stakeholders and automation (e.g., decision support systems), using airspace and airport design requirements, standards, and configuration conditions with the consideration of other air transportation system resources.

Provide Collaborative Flow Contingency Management: Flow contingency management provides optimal, synchronized, and safe strategic flow initiatives and ensures the efficient management of major flows of traffic while minimizing the impact on other operations in collaboration with enterprise stakeholders, through real- or near-real-time resolutions informed by probabilistic decision making within established capacity management plans.

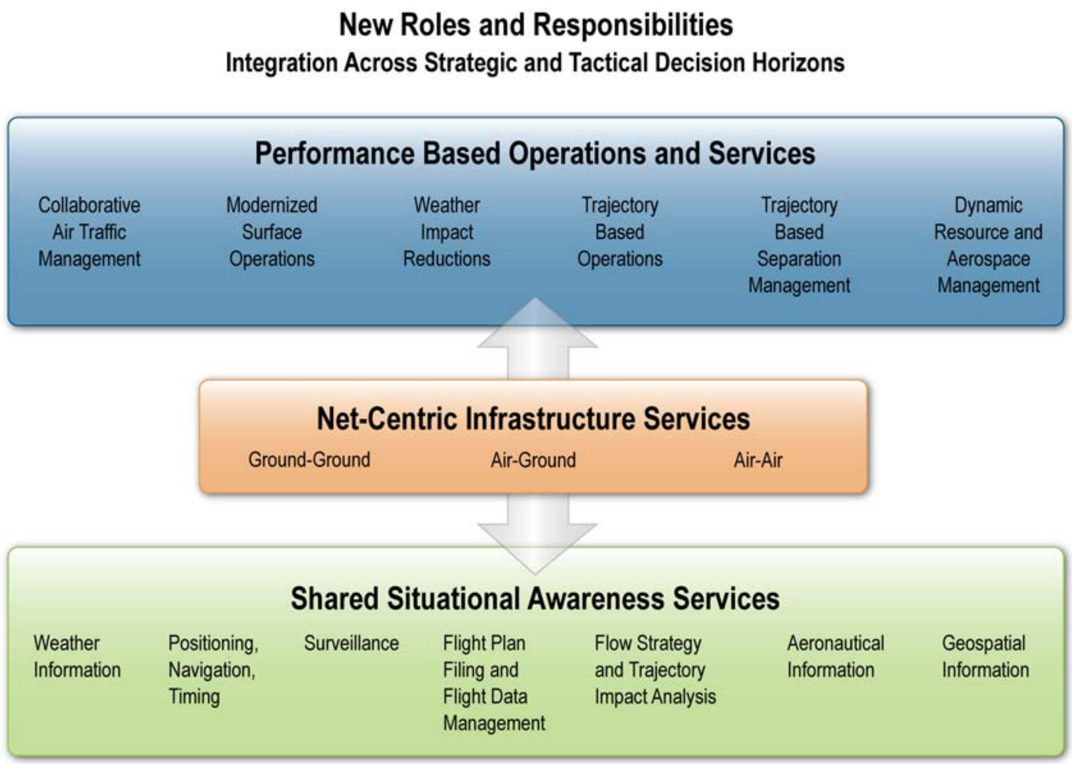
Provide Efficient Trajectory Management: Efficient trajectory management provides the ability to assign trajectories that minimize the frequency and complexity of aircraft conflicts within the flow through the negotiation and adjustment of individual aircraft trajectories and/or sequences when required by resource constraints.

Provide Flexible Separation Management: Flexible separation management establishes and maintains safe separation minimums from other aircraft, vehicles, protected airspace, terrain, weather, etc., by predicting conflicts and identifying resolutions (e.g., course, speed, altitude, etc.) in real time, and accommodates increasing capacity demands and traffic levels by using automation (e.g., decision support systems) while also introducing reduced separation standards.

The ATM Capabilities for collaborative capacity, flow contingency, trajectory, and separation management describe at a high level the NextGen vision for managing the increases in demand by maximizing the use of available airspace, while increasing the safety, security, capacity, efficiency, and environmental compatibility of air transportation operations. The overall

evolution of the roles and responsibilities of Air Navigation Service Providers (ANSPs) and NAS users are also improved. Automation is used to a greater extent to manage complexity and expand the information that is available, and individual roles migrate to more strategic management and decision making. As part of this shift in roles, the flight crew is more integrated into ATM, leveraging onboard aircraft capabilities to achieve a scalable[3] system design.

Figure 2-1 Air Traffic Management Operations and Services



Additionally, aircraft equipage would provide improvements to the ATM process and result in enhancements of ANSP services. Typical aircraft equipage functionality and user benefits for most aircraft would include:

- Area Navigation (RNAV)/Required Navigation Performance (RNP) and Automatic Dependent Surveillance-Broadcast (ADS-B) In/Cockpit Display Traffic Information (CDTI)
- Improved data communications
- Enhanced weather sensors
- Improved navigation ability (accuracy and integrity)
- Satellite-based precision instrument approach ability

[3] In this instance, scalability refers to the ATM ability to respond quickly and efficiently to increases in demand.

These additional equipage functionalities provide improvements in aircraft to ANSP information exchange, access, and throughput at non-towered or uncontrolled airports, and weather forecasting for reduced weather impacts. Direct and indirect benefits to the aircraft associated with improved overall NAS efficiency are also provided. These benefits include:

- Improved controller productivity
- Improved operational efficiency in convective weather by reducing flight time
- Improved operational predictability enabled by reduced impact of disruptions
- Improved access to congested resources for more capable (or higher-performing) aircraft
- Reduced fuel usage and related costs through reduction in delay
- Optimal flight paths
- Increased flexibility for aircraft self-separation

Collaborative Air Traffic Management. With the increase and diversification in the number of airspace users—each possessing a unique operating need—and the increased importance and impact of other airspace uses, collaborative air traffic management (C-ATM) mechanisms support a diverse set of participants. The participants share a common awareness of overall constraints and the impacts of individual and system-wide decisions. Decision making among these participants significantly improves in this C-ATM environment, which builds on automation tools and system-wide information exchange capabilities, enabling participants to better understand the prevailing constraints, short- and long-term effect of decisions, and interdependence among national, regional, and local operations. Use of advanced automation, to manage information across all phases of flight and contingency planning also results in a system that is more agile in responding to changes in environment or demand.

High-Performance Trajectory Based Operations. Perhaps the most fundamental requirement of NextGen is to safely accommodate significantly increased traffic, and to do this in airspace that is already congested, such as between heavily traveled city pairs (e.g., Washington DC and Chicago) and near the busiest airports. This requirement leads to a transformation in operations to High-Performance Trajectory Based Operations (HP-TBO) in high-density airspace where precise management of an aircraft's current and future position enables increases in throughput. This trajectory prediction ability facilitates separation assurance in this airspace and allows delegation for separation to capable aircraft for some operations, further improving efficiency and throughput. Within HP-TBO, peak demand at the busiest airports is accommodated through *super-density arrival/departure operations* in which advanced aircraft and ANSP capabilities support optimized and efficient runway throughput.

Using HP-TBO four-dimensional trajectories (4DTs) and probabilistic decision making for weather events, entire flows of aircraft and individual trajectories can be dynamically adjusted, providing an advantage for opportunities to safely meet constraints while efficiently reducing the overall impact of such events. These operations replace the broad, static directives that are characteristic of today's operations.

To accomplish these trajectory actions, digital data exchange of trajectories becomes the primary mode of communication between the ANSP and flight operators, replacing verbal delivery of clearances. HP-TBO is used in parts of en route, oceanic, and arrival/departure[4] airspace, as well as some surface operations. Trajectory Based Operations (TBO) is used in all airspace (i.e., all aircraft have some form of trajectory defined for their flight), but HP-TBO is only used in parts of airspace.

ATM Service Delivery. TBO enables the integration of trajectory planning and execution across the spectrum of time horizons, from strategic planning to tactical decision making. ATM service delivery is described with four functions covering this spectrum, as shown in Figure 2-2. An integral part of the transformation is that real-time performance measurement is used to assess the effectiveness, efficiency, and capacity of the system against established performance metrics. The results of the analysis are used in the collaboration among the ANSP and flight operators for integrated decision making between the functions. The functions are:

- **Capacity Management (CM)** is the design and configuration of airspace and the allocation of other NAS resources. CM is the preferred means of responding to dynamic forecast demand—resources and performance-based services are matched with the expected demand (Section 2.2.12.1).

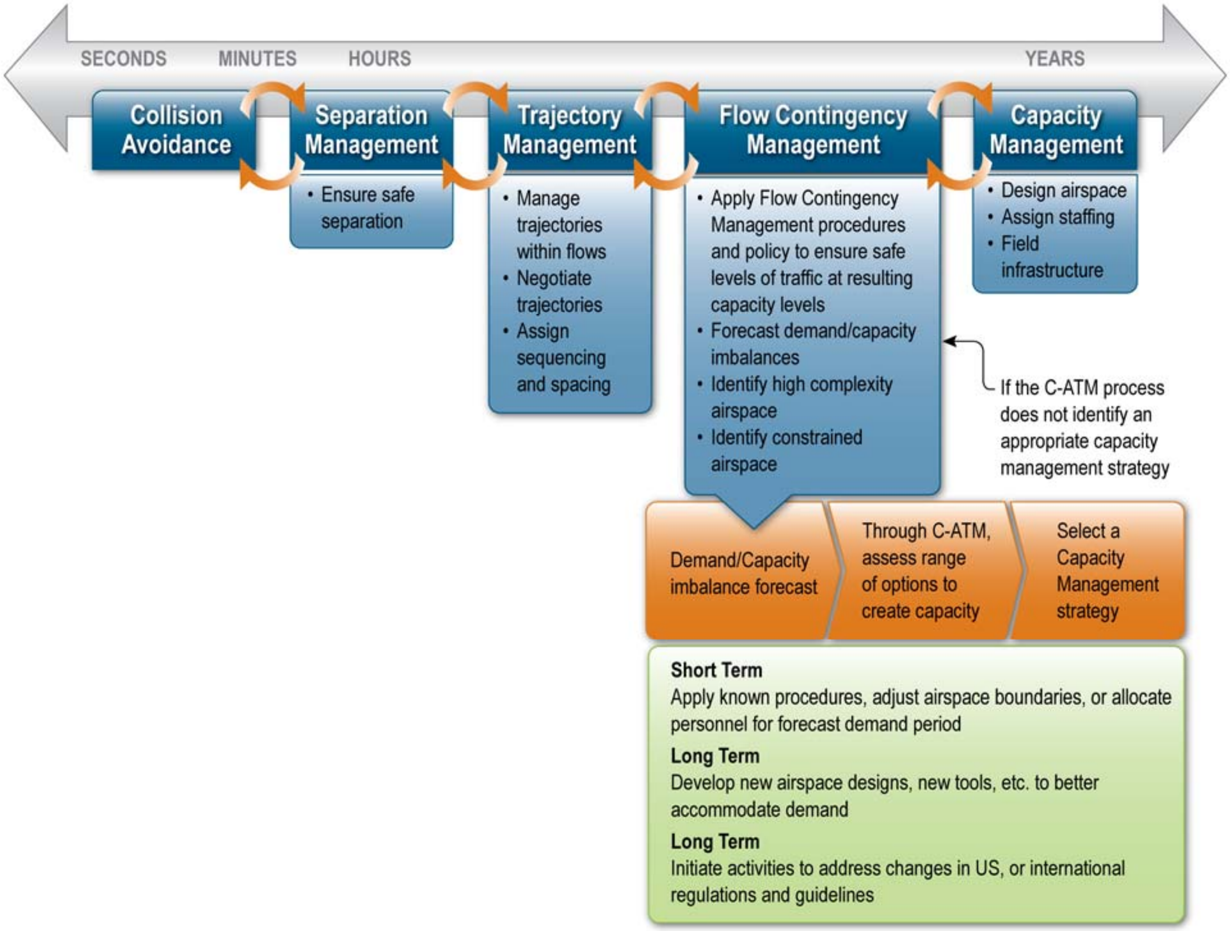
- **Flow Contingency Management (FCM)** comprises strategic flow initiatives addressing large demand/capacity imbalances within CM plans resulting from severe or localized weather conditions and airspace restrictions. FCM ensures the efficient management of major flows of traffic while minimizing the impact on other operations (Section 2.2.2).

- **Trajectory Management (TM)** is the adjustment of individual aircraft within a flow to provide efficient trajectories, manage complexity, and ensure that conflicts can be safely resolved (Section 2.3.1).

- **Separation Management (SM)** is the provision of safe distance between aircraft. SM tactically resolves conflicts among aircraft and ensures avoidance of weather, airspace, terrain, or other hazards (Section 2.3.2).

[4] Arrival/departure airspace is airspace including climb-out to eventual en route altitude and from the start of descent to the airport surface. It includes only the arrival and departure corridors leading to the currently used runways.

Figure 2-2 ATM Decisions—Interactive and Integrated Across Time Horizons



<u>Key ATM Services Principles</u>

A number of key principles are associated with the delivery of ATM services in NextGen:

- NextGen resources are managed to maximize utility to flight operators. Restrictions are imposed only for projected congestion or to meet safety, security, or environmental constraints.
- NextGen supports a range of operator goals and business models and does not inherently favor one business model over another; however, public policy may provide incentives for one or more business models, if desired.
- NextGen stakeholders maximize their ability to achieve their goals and business objectives by actively participating in the C-ATM process. This involves not only information exchange and negotiation with respect to flight trajectories but also involvement in the process of allocating ATM resources. Tools are in place in NextGen to allow virtually any operator to participate in the C-ATM process.

- When excess demand exists that cannot be addressed by using performance-based operations and applying C-ATM, known policies prioritize access to NextGen resources among all operators.
- All national objectives for NextGen are considered in addressing access to NAS resources. For example, military, state, and civil aircraft that are involved in national security, homeland defense, response to national disasters, police actions, life-guarding actions, and movement of high-ranking government officials receive appropriate priority.
- Airspace is a national resource to be used for the "public good." Government mandates are an acceptable means of meeting "public good" objectives when incentives are insufficient.

<u>Key ATM Services Assumptions</u>

Key assumptions for the NextGen ATM system and services include the following:

- *Performance-based operations* are the basis for defining requirements. In particular, Communication, Navigation, and Surveillance (CNS) performance becomes the basis for operational approval, rather than specific equipage or technologies. Performance-based operations simplify regulatory activities in the presence of technology proliferation and allow the opportunity to define "pre-approved" operations based on performance levels.
- The ANSP provides performance-based services, allowing operational benefits to aircraft that have advanced capabilities. For a given airspace volume, the minimum level of ability may vary depending on overall demand characteristics and the environment. Flight operators choose ability levels for their aircraft according to their needs and to make the economic tradeoff between level of service and aircraft investment.
- Network-enabled services in NextGen provide a broad ability to move, store, and access information. All stakeholders have a consistent view of factors that affect their decision making, while data security and privacy mechanisms ensure that information is not misused or inappropriately disclosed.
- Advanced automation performs routine tasks and supports distributed decision making between flight operators and the ANSP. New automation procedures and systems are in use by both aircraft and the ANSP, enabling TBO and other transformations critical to achieving NextGen objectives.
- There is a wider range of aircraft capabilities and performance levels than exists today.
- Environmental outcomes are increasingly important in designing and conducting ATM operations.
- International interoperability in performance-based operations is a requirement as capabilities and procedures are defined.

Dynamic Resource Management. The move toward dynamic resource management supports the need to provide improved services to all NextGen users. In NextGen, ATM system resources and services are delivered to meet demand, rather than constraining demand to match the available resources (including people, facilities, and airspace). Delivery of services is no longer tied directly to the geographic location of the aircraft. ANSP personnel acquire needed information and communicate with flight operators independent of their facility location.

Weather Impact Reductions. Within NextGen, the impact of weather is reduced through the use of improved information sharing, new technology to sense and mitigate the impacts of weather, improved weather forecasts, and improved decision making through the integration of weather into automation. The impacts of instrument meteorological conditions (IMC), for example, are limited via aircraft and ANSP capabilities that allow operations independent of visibility (e.g., the use of electronic flight rules for Unmanned Aircraft Systems [UAS]). Using automation, to better manage uncertainties associated with weather minimizes airspace capacity limitations and reduces the likelihood of overly conservative actions.

Key aircraft flight deck advancements that may improve airport accessibility include aircraft-based technologies such as head-up display (HUD) or auto land capabilities, enhanced flight vision systems (EFVS), and synthetic vision systems (SVS), as well as the ground-based augmentation system (GBAS) in combination with global positioning system (GPS). These new aircraft flight technologies will allow greater access and throughput at airports that would otherwise be unavailable due to insufficient ground infrastructure. By equipping with technologies such as HUDs or EFVS, the aircraft operator will have greater flexibility and predictability of operations at a variety of airports with less dependence on existing ground infrastructure.

Modernized Surface Operations. Finally, another transformation in ATM is the advent of modernized surface operations. Surface operations move from a highly visual, tactical environment to a more strategic set of operations enabled by enhanced or synthetic vision in low/no-visibility conditions that will better achieve operator and ANSP efficiency objectives, and better integrate surface, airspace, and traffic flow decision making. Surface and tower services are delivered more affordably, enabling access to ANSP services at more airports than is practical today, resulting in greater value to flight operators and airport operators.

2.2 COLLABORATIVE AIR TRAFFIC MANAGEMENT

In NextGen, all airspace users are able to collaborate on ATM decisions. This ability ranges from today's large-scale Flight Operations Centers (FOC) with a complete set of C-ATM automation tools to individual pilots with hand-held and home personal computers for appropriately scaled C-ATM collaboration access. Those who participate in the collaboration process are better able to achieve their own objectives within the constraints imposed by overall traffic demand or short-term effects such as weather or airspace restrictions.

Collaboration involves the exchange of information to create mutual understanding of overall objectives among participants and to share decision making among stakeholders. With the collaborative capabilities in NextGen, stakeholders are aware of constraints, system strategies,

and the performance metrics that describe the past and predicted behavior of the ATM system. The service provider is aware of stakeholder route preferences, performance capabilities, and flight-specific performance limitations. Key stakeholders in ATM decision making include the ANSP, flight operators (including both flight planners and flight crews), airport operators and regional authorities, security providers, and U.S. military and state organizations. These groups and others collaborate in developing and assessing strategies to expand NAS capacity, addressing short-term demand and capacity imbalances, balancing national and civil needs in the use of special use airspace (SUA), and coordinating appropriate responses to address security needs.

Key benefits from the collaborative environment in NextGen include the following:

- Airspace users benefit from improved collaborative decision support tools (DST), which better assess the potential impacts of decisions, reducing the likelihood of unintended consequences. Better DSTs also increase the system’s ability to maintain capacity and increase predictability in the presence of continuous uncertainty. Less-conservative operational decisions are made because decision support capabilities can better integrate large amounts of data over multiple time horizons.

- Today’s collaboration process is characterized by poor information distribution and is limited by verbal negotiations. The future system will be characterized by increased participation where flight operators gain benefits in efficiency, access, and overall performance and other national needs are accommodated effectively.

- Information exchange is more clearly targeted to the appropriate decision makers, reducing workload and unnecessary actions by those not affected. Machine-to-machine negotiation replaces labor-intensive, voice, or text-based processes.

- Needs for managing airspace security are integrated into overall collaboration and decision making.

- Participants are assured of data privacy and protection, so that sensitive or proprietary information can be utilized in a way that helps to achieve their objectives.

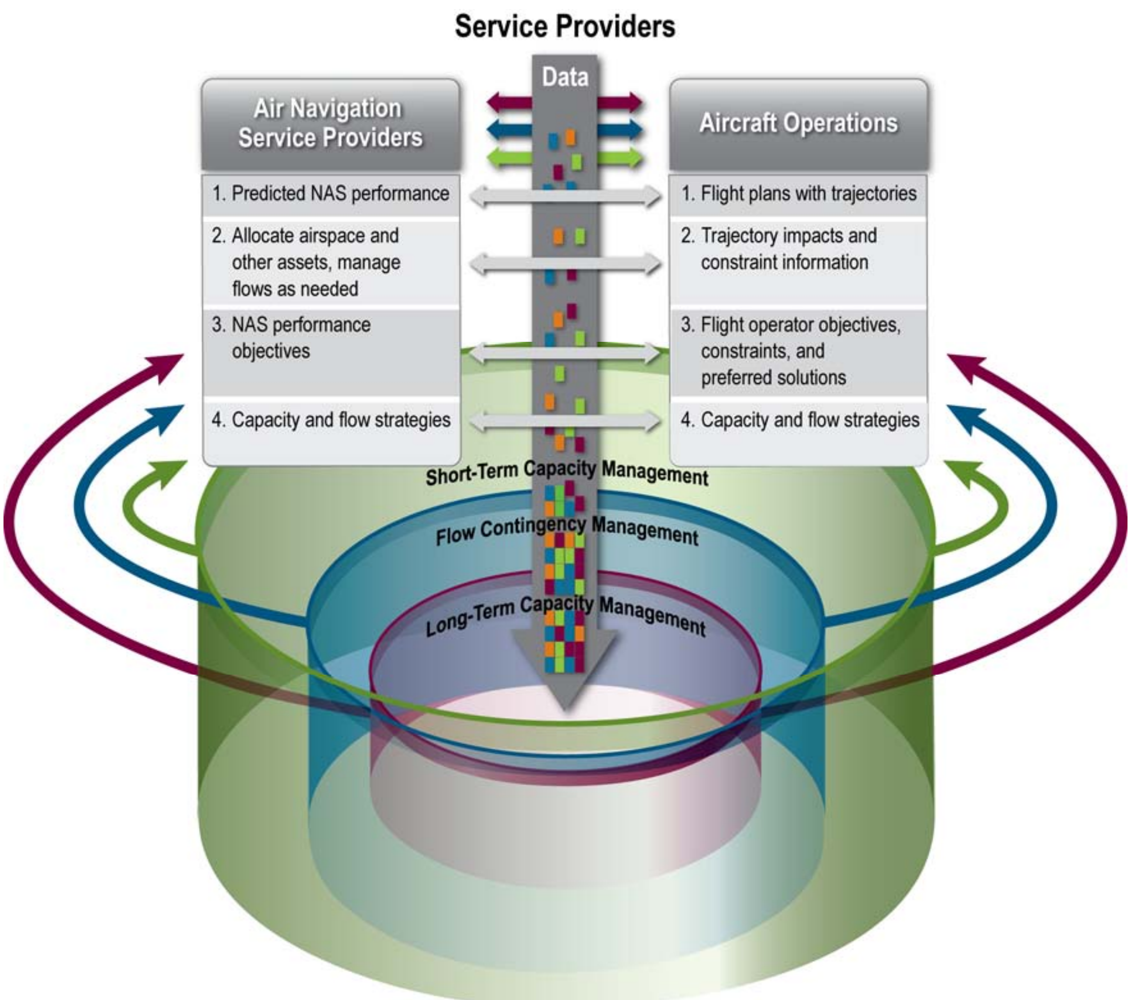
- By participating in the collaborative process and providing user preferences, the airspace users benefit from flying their desired routes based on their business need.

C-ATM is the means by which flight operator objectives are balanced with overall NAS performance objectives and accomplishes many of the objectives for CM, FCM, and TM. Flight planners or an operator’s flight planning automation interact with the ANSP via a set of services that provide all stakeholders with the opportunity to participate in the C-ATM process. Among these services is a common flow strategy and trajectory analysis service that enables Shared Situational Awareness (SSA) of current and projected NAS status and constraints. This service provides stakeholders with the ability to examine the individual or aggregate impacts of proposed strategies for CM or FCM.

With information sharing, flight operators and the ANSP have a common understanding of overall national goals and desired performance objectives for the NAS. A transparent set of

strategies is in place to achieve overall performance objectives, including airspace management to maximize capacity when demand is high and, as required, flow management initiatives to ensure that safe levels of traffic are not exceeded when capacity limits are reached. ANSPs are better able to communicate and collaborate on the effects of procedures for flights transiting airspaces managed by different ANSP entities (e.g., for different flight information regions [FIRs], for specially managed special activity airspace [SAA]). Figure 2-3 provides a pictorial view of C-ATM.

Figure 2-3 Collaborative ATM Among the ANSP and Operators



The rest of this section provides greater depth on the C-ATM process. Section 2.2.1 describes the CM process. Section 2.2.2 describes the FCM process. FCM is used only when CM cannot fully adjust resources to match anticipated demand.

2.2.1 Capacity Management

CM has two components, short term and long term. "Short-term" CM is the reallocation of assets and the use of procedures to maximize capacity to match anticipated demand. In contrast, "long-

term" CM includes planning for major changes to airspace design, significant airport infrastructure improvements, and the establishment of new operational procedures. The CM process allocates NAS resources to meet overall system goals based on user plans, including the designation of airspace (e.g., for HP-TBO) and the determination of procedures required for access to airspace. CM structures routings, where required, to manage complexity and reserves airspace, as needed, for special uses. CM responds to an aggregation of airspace users' expected or desired trajectories, infrastructure, geographic, and environmental constraints, and it provides airspace assignments and dynamic routings to manage the resulting demand.

The CM process begins years before flights are in operation and continues up to and including the day of operation. It includes the long-term and short-term management and assignment of NAS airspace and trajectories to meet expected demand, assignments of related NAS assets, and coordination of long-term staffing plans for the airspace assignments. Significant structural changes to airspace or operations (e.g., building a new runway or introducing a new flight procedure) are planned years in advance. The best usable solutions are selected through iterative collaboration across decision horizons.

2.2.1.1 Short-Term Capacity Management

Short-term CM involves the allocation of existing assets (e.g., allocation of personnel, adjustment of airspace structures, or designation of performance-based services) to appropriately create the required capacity to meet anticipated demand. In NextGen, resource management is flexible and dynamic, which enables the ATM system to apply people where their services are most needed, to manage and configure facilities appropriately, and to designate the use and design of airspace to complement operations. Delivery of services is no longer tied directly to the geographic location of the flight operator or the aircraft; instead ANSP personnel have the ability to acquire needed information and communicate with flight operators independent of their facility location.

As operators plan flights, they share information with the ANSP about the planned trajectory of the aircraft. These trajectories may have different levels of precision based on the expected operations to be performed. For TBOs, the operator's flight plan includes a 4DT. As more information about the conditions affecting a flight becomes available, operators are automatically informed and in turn, make adjustments to provide "best-known" information updating their flight plans. In general, operators use predefined routes less and have more flexibility in designating preferred routings. Some route structure remains, where needed, to manage complexity, especially at lower altitudes and in terminal airspace where ANSP personnel require more knowledge about the airspace, and where environmental restrictions exist. Airspace designated for high-capacity or high-complexity operations may hold a HP-TBO designation for a certain set of hours in the day or over a set period of days. This dynamic use of airspace is complemented with the move toward performance-based services that specify minimum performance criteria that an aircraft is required to meet for operating in a volume of airspace. Further, this dynamic nature is transparent—flight operators have the ability to plan and execute their flights.

CM and FCM functions are interactive, as are airspace and TM functions. The demand-capacity balancing process determines which CM strategies to employ across the NAS. Part of the CM

process also includes the use of metrics and analyses to determine which strategies were most effective under which conditions. Examples of CM strategies include the following:

- Increasing the capacity of a given area of airspace to accommodate projected traffic growth through reassignment of resources (e.g., personnel, RNP routes)
- Instituting structured routes to reduce traffic complexity
- Establishing flow corridors to better accommodate high levels of traffic
- Adjusting the boundaries or activation times of SAA
- Balancing workload among ANSP personnel for a forecast demand “surge”

An important area of short-term collaboration for CM is in addressing the use of SUA and assessing the impacts of proposed SUA. For example, if a military flight operator plans to reserve airspace for a set of operations, the military operator and the ANSP negotiate to balance the need to reserve the airspace with other civil needs for the airspace. The ANSP and the military operator may agree to adjust the airspace boundaries or the time of operations to accommodate civil needs, however, a military need may also outweigh a civil need and preempt other planned uses. Criteria for this process are defined between the military and service providers.

Collaboration among the ANSP, flight operators, defense services providers, and security services providers is key in determining effective use of airspace for security and defense needs. A default strategy of static restrictions is no longer used to address security needs. Instead, management of security and defense needs is based on flight-specific access requirements, where practical (also see Chapter 6.3.5 for secure airspace concepts). The overall goal for airspace collaboration is to minimize disruption of air traffic while recognizing national defense needs to train pilots and protect the security of sensitive assets, significant activities, and critical infrastructure. Defense and homeland security airspace restrictions are dynamically managed to enhance airspace access. Restrictions for accessing airspace are based on risk and managed flexibly to accommodate security and defense needs in a non-disruptive manner. Flight operators receive this information, so they can better plan flights and be aware of likely restrictions.

Both defense and homeland security restrictions are dynamically managed to enhance airspace access. Restrictions, for accessing airspace, are managed flexibly to accommodate security and defense needs in a non-disruptive manner. When airspace restrictions are proposed to address security concerns, the impacts of a proposed restriction are weighed against the risks that have been identified, and mitigations are identified to reduce the impact on flight operator plans. The philosophy for airspace restrictions is to provide the maximum available airspace to all users at all times, meet national security needs via priority 4DT reservations, and facilitate immediate user notification of “just-in-time” national needs for restricted airspace. In addition to improved SSA and automated conformance monitoring, management of security and defense needs evolves, wherever possible, toward flight-specific access requirements and away from blanket restrictions for airspace access.

2.2.1.2 Long-Term Capacity Management

Long-term CM generally requires months to several years to implement, depending on the solution set (e.g., build a new runway, develop a new automation system). CM solutions requiring the development of new operational procedures, design of airspace, or implementation of a new technology require the ANSP to perform pre-implementation activities including research and development (R&D), environmental impact assessment and mitigation, and safety and security analysis. The solutions typically also involve external collaboration with manufacturers, flight operators, regulators, or other stakeholders. As proposed changes are defined, the ANSP addresses U.S. or international regulatory and policy bodies in a more effective and streamlined manner than is possible today.

2.2.2 Flow Contingency Management

FCM is the process that identifies and resolves congestion or complexity resulting from blocked or constrained airspace or other off-nominal conditions. FCM deals with demand-capacity imbalances that cannot be addressed through the CM process. FCM involves managing the conflicting objectives of multiple stakeholders, regarding the operational use of over-subscribed airspace and airports, while taking advantage of available capacity to address demand. The collaborative process among flow contingency managers, flight operators, and airport operators allows flight operators to find solutions that best meet their priorities and constraints while satisfying the conditions specified in a given FCM plan.

Several guiding principles govern the concept of FCM:

- FCM addresses multiple types of constraints, including airspace, airport, and metroplex constraints.
- FCM becomes more agile in dealing with uncertainties, developing adaptive traffic management plans that use capacity as it becomes available, and safely dealing with scenarios that become more constrained than expected.
- FCM provides equitable treatment of flight operators and, as much as possible, gives them the flexibility to meet their objectives.
- FCM becomes more focused, affecting only the flights necessary to deal with a constraint.

FCM strategies can include establishing multiple trajectories and/or flow corridors to reduce complexity (Section 2.2.2), restructuring the airspace to provide more system capacity, or allocating time-of-arrival and departure slots to runways or airspace. Operators with multiple aircraft involved in an initiative have the flexibility to adjust individual aircraft schedules and trajectories, within those allocations, to accommodate their own internal priorities. The ability for automation to monitor conditions and identify new trends facilitates dynamic refinement of traffic management initiatives (TMI) and reduces the likelihood that TMIs are overly conservative in managing the NAS. Various FCM functions and activities may occur months or days in advance of a flight or during a flight. As with all TMIs, probabilistic decision making is used to assess the likely regional and local effects of anticipated flows, weather patterns, and

other potential constraints and take incremental actions to reduce the probability of congestion to acceptable levels without overprotecting NAS resources.

FCM can also be achieved by integrating the aircraft's navigation ability with data link. The precision and reliability of RNP routes, for example, can also be applied to dynamically defined routes to enhance user access and air traffic management. Many current aircraft have some functionality (e.g., Future Air Navigation System [FANS-1A]) to negotiate a trajectory. A negotiated trajectory may be as simple as an expected path from top-of-descent or as complex as a 4DT path.

2.3 TRAJECTORY-BASED OPERATIONS

Trajectory Based Operations (TBO) are route based and verbal clearances. Currently, separation is handled by controllers using radar screens to visualize trajectories and make cognitive operational judgments, with some automation decision support to help identify and resolve future conflicts.

A major transformation in NextGen is the use of HP-TBO as the main mechanism for managing traffic in high–density or high-complexity airspace. HP-TBO represents a further shift in TBO from clearance-based to trajectory-based control. Aircraft will fly negotiated trajectories as air traffic control moves to trajectory management, with the use of 4DTs as the basis for planning and executing all flight operations. The traditional responsibilities and practices of pilots/controllers will evolve due to the increase in automation, support, and integration inherent to trajectory management.

In high–density or high-complexity airspace, HP-TBO aligns all TM functions across all time horizons based upon the aircraft's 4DT. Digital data communication and ground-based and airborne automation to create, exchange, and execute 4DTs are prerequisites for HP-TBOs. The use of precise 4DTs dramatically reduces the uncertainty of an aircraft's future flight path, in terms of predicted spatial position (latitude, longitude, and altitude) and times along points in its path. This enables airspace to be used much more effectively than is possible today to safely accommodate high levels of demand and maximize the use of capacity-limited airspace and airport resources. HP-TBO and super-density arrival/departure operations are likely to be used during peak periods at the busiest metropolitan areas. High-altitude en route and oceanic airspace, and areas where major flows occur, also use HP-TBO. With HP-TBO, less airspace is needed for these major flows, resulting in reduced impact and improved access for other flights.

With TBO, differing types of operations are conducted, distinguished by the manner in which procedures are selected and clearances are initiated, transmitted, negotiated, monitored, and revised. Performance-based services are applied based on the anticipated traffic characteristics; minimum requirements for operations and procedures to be used are selected to achieve the necessary level of capacity. Overall, preferences for all users are accommodated to the greatest extent possible, and trajectories are constrained only to the extent required to accommodate demand or other national concerns, such as safety, security, or environmental concerns. With TBO, the ANSP provides services to aircraft of differing ability in proximity to each other.

Operators that equip their fleets to conduct TBO receive services from the ANSP that allow them to achieve operating benefits.

A major element of TBO is trajectory-based SM, which uses automation and shared trajectory information to better manage separation among aircraft, airspace, and hazards such as weather and terrain. Trajectory-based SM also includes delegation of separation tasks to the flight crew. Improved information sharing, improved sensors and forecasting, and better integration of weather into automated DSTs help reduce the impact of weather on the entire system. Finally, the ATM framework builds on surface operations that are modernized and better integrated into airspace operations to achieve efficiencies not possible today. A number of capacity, efficiency, and general benefits have resulted from the increased predictability of operations, which is based on use of precise trajectories. These benefits include safety and increased ANSP productivity. Benefits from the use of TBO includes the following:

- **Capacity/Better Airspace and Runway Utilization.** One of the primary uses of TBO is to increase the inherent capacity of airspace to better accommodate demand from flight operators. As a result, TBO and trajectory-based planning, together with improved weather information integrated into decision making and integration of military, security, environmental, and other requirements, allow access to more airspace more of the time, with reduced impact to traffic flows. The flexible management of aggregate trajectories enabled by TBO allows the ANSP to maximize access for all traffic, while adhering to the principle of giving advantage to those aircraft with advanced capabilities that support the ATM system. TBO minimizes excess separation resulting from today's control imprecision and lack of predictability and enables reduced separation among aircraft, allowing increased capacity. TBO is also a key element of super-density arrival/departure procedures. Implementing super-density arrival/departure procedures enables new runways to be built much closer to existing runways and potentially reduces the cost of new runway construction.

- **Efficiency and Environment.** Operational management of TBO (via an aircraft's 4DT) enables efficient control and spacing of individual flights, especially in congested arrival/departure airspace and busy runways. This enables use of noise-sensitive and/or reduced-emissions arrival/ departure flight paths. For long flights, particularly in oceanic airspace, the increased predictability afforded by TBO improves fuel efficiency and facilitates optimal fuel loading. Overall, flight operations are more consistent and operators are able to maintain schedule integrity without the excess built into today's published flight times.

- **Other Benefits.** In addition to supporting increased flows, TBO enables collaboration between the ANSP and operators to maximize utility of airspace to meet ANSP productivity and operator goals. TBO also allows for scalability of the entire system, as operators become more active in collaborations with the ANSP to manage their own trajectories. Finally, TBO is seen as a key enabler to increase ANSP productivity, so services can be provided at a much lower per–operation cost.

2.3.1 Trajectory Management Process

TM is the process by which individual aircraft trajectories are managed just before and during the flight to ensure efficient individual trajectories within a flow. TM corrects imbalances within an established flow to ensure that congestion is manageable. The TM process considers any active FCM initiatives and known airspace plans in establishing the best mitigation to resource contention. TM assigns trajectories for aircraft transitioning out of self-separation operations and for aircraft entering or leaving flow corridors. For arrival/departure operations, including super-density operations, TM assigns each arriving aircraft to an appropriate runway, arrival stream, and place in sequence. TM supports SM by reducing, but not eliminating, the need for tactical separation maneuvers.

2.3.2 Separation Management Process

The SM process ensures that aircraft maintain safe separation from other aircraft, from certain designated airspace, and from any hazards (e.g., terrain, weather, or obstructions). Where HP-TBO is used, SM relies significantly on automation for predicting conflicts and identifying solutions. Use of automation also allows SM to move away from fixed human-based standards to ones that allow variable separations that factor in aircraft capabilities, encounter geometries, and environmental conditions. Flight crews approve the recommended conflict resolution before it is implemented, whether it is generated on the ground or in the cockpit.

In managed airspace, the ANSP has overall responsibility for SM and may delegate this responsibility to separation-capable aircraft. The operating norm is that the ANSP delegates tasks to aircraft to take advantage of aircraft capabilities. ANSP automation manages separation and negotiates short-term, conflict-driven updates to the 4DT agreements with the aircraft. Delegated separation operations include both a single aircraft having separation authority for a specific maneuver (e.g., for crossing or passing another aircraft) or more general separation responsibility, such as for flow corridors (Section 2.3.3.2). ANSP and aircraft automation track the delegation of responsibility and its limits and ensure that the delegation is always unambiguous.

Aircraft performing self-separation procedures separate themselves from one another as well as from aircraft whose separation is managed by the ANSP without intervention by the ANSP. The ANSP provides neither separation nor TM services in self-separation airspace, but the aircraft may still be subject to TM in downstream transition airspace. Standardized algorithms detect and provide resolutions to conflicts at least several minutes ahead of the predicted loss of separation. The resolution maneuver is usually very small (because of the increased precision in TBO) and generally includes course, speed, or altitude changes. Rigorous right-of-way rules determine which aircraft should maneuver to maintain separation when a conflict is predicted. These rules specify the conflict resolution maneuver options for resolving the conflict with minimum disruption to the maneuvering aircraft and for preventing a conflict with a third aircraft in the short term. Contingency procedures, requiring the other aircraft to execute an avoidance maneuver, are invoked in the event the “burdened” aircraft does not make the appropriate maneuver within a specified time.

Self-separating aircraft have 4DTs with sufficient flexibility defined to allow for separation maneuvers. After such maneuvers, the aircraft is expected to return to its route toward its next waypoint defined in the 4DT or negotiate a new 4DT. Usually the aircraft is able to achieve and maintain its most efficient trajectory without renegotiating its 4DT. In oceanic or remote airspace, the aircraft may have sufficient flexibility to deviate around weather. A FCM function may be needed in self-separation airspace to impose sufficient structure to ensure that traffic density remains safe, especially around convective weather or other constraints.

Transition airspace around self-separation airspace exists to allow for the safe transfer of separation responsibility between the aircraft and the ANSP. For aircraft entering self-separation airspace, separation responsibility is transferred so that the aircraft is safely able to assume it, implying that there are no very near-term conflicts with other aircraft or hazards. For aircraft exiting self-separation operations, the transition may include waypoints with controlled time of arrivals (CTA) to enable sequencing and scheduling by the ANSP. In this transition zone, the ANSP provides CTAs and possibly TM to maintain safe separation between the aircraft exiting the airspace. As with delegated separation, the ANSP and aircraft automation track the transfer of separation responsibility and communicate it to those affected.

Today, most high-performance aircraft are equipped with an aircraft-based collision avoidance system that is independent of the air traffic control (ATC) system. In the United States, this system is referred to as the Traffic Alert and Collision Avoidance System (TCAS) II. Internationally, this system is referred to as the Airborne Collision Avoidance System (ACAS). TCAS II reduces the risk of collision between aircraft when the separation assurance process fails. Under NextGen, a collision avoidance system independent of the separation assurance system, and which acts only in the event the separation assurance process fails, will still likely be required (see ICAO AN-Conf/11, ASAS Circular).

2.3.3 TBO Aircraft Procedures

The procedures performed by 4DT-capable aircraft are described in this section. The procedures used most include:

- **4DT Procedures.** In addition to basic RNP ability, aircraft must meet specified timing constraints at designated waypoints along their route. Aircraft comply with the resulting 4DT procedure in flight. Several levels of 4DT operations exist, defined by the level of navigational and timing constraints.

- **Delegated Separation Procedures.** The ANSP delegates responsibility to capable aircraft, performing the basic 4DT procedures described above, to perform specific separation operations using onboard displays and automation support. Examples include passing, crossing, climbing, descending, and turning behind another aircraft. In these operations, the ANSP is responsible for separation from all other traffic while the designated aircraft performs the specific maneuver.

- **Airborne Merging and Spacing Procedures.** 4DT aircraft are instructed to achieve and maintain a given spacing, in time or distance, from a designated lead aircraft as defined by an ANSP clearance. Cockpit displays and automation support the aircraft conducting

the merging and spacing procedure to enable accurate adherence to the required spacing. Separation responsibility remains with the ANSP.

- **Airborne Self-Separation Procedures.** Aircraft are required to maintain separation from all other aircraft (and other obstacles or hazards) in the airspace. Aircraft follow the “rules of the road” and avoid any maneuvers that generate immediate conflicts with any other aircraft. The ANSP does not provide TM or SM, except as needed to safely sequence and schedule aircraft exiting self-separation airspace.

- **Low-Visibility Approach/Departure Procedures.** Aircraft with appropriate cockpit displays and automation support conduct landings and takeoffs safely in low-visibility conditions without relying on ground-based infrastructure by using onboard navigation, sensing, and display capabilities.

- **Super-Density Arrival/Departure Procedures.** Aircraft conduct delegated separation procedures, such as closely spaced parallel approaches, within very precise tolerances for position and timing to maximize runway throughput.

- **Surface Procedures.** Trajectory-based procedures may be used on the airport surface, at high-density airports, to expedite traffic and schedule active runway crossings. Equipped aircraft may perform delegated separation procedures, especially in low-visibility conditions.

The procedures listed above are not mutually exclusive, and the flight object captures the abilities and authority of aircraft to perform these procedures.

2.3.3.1 Four-Dimensional Trajectories (4DT)

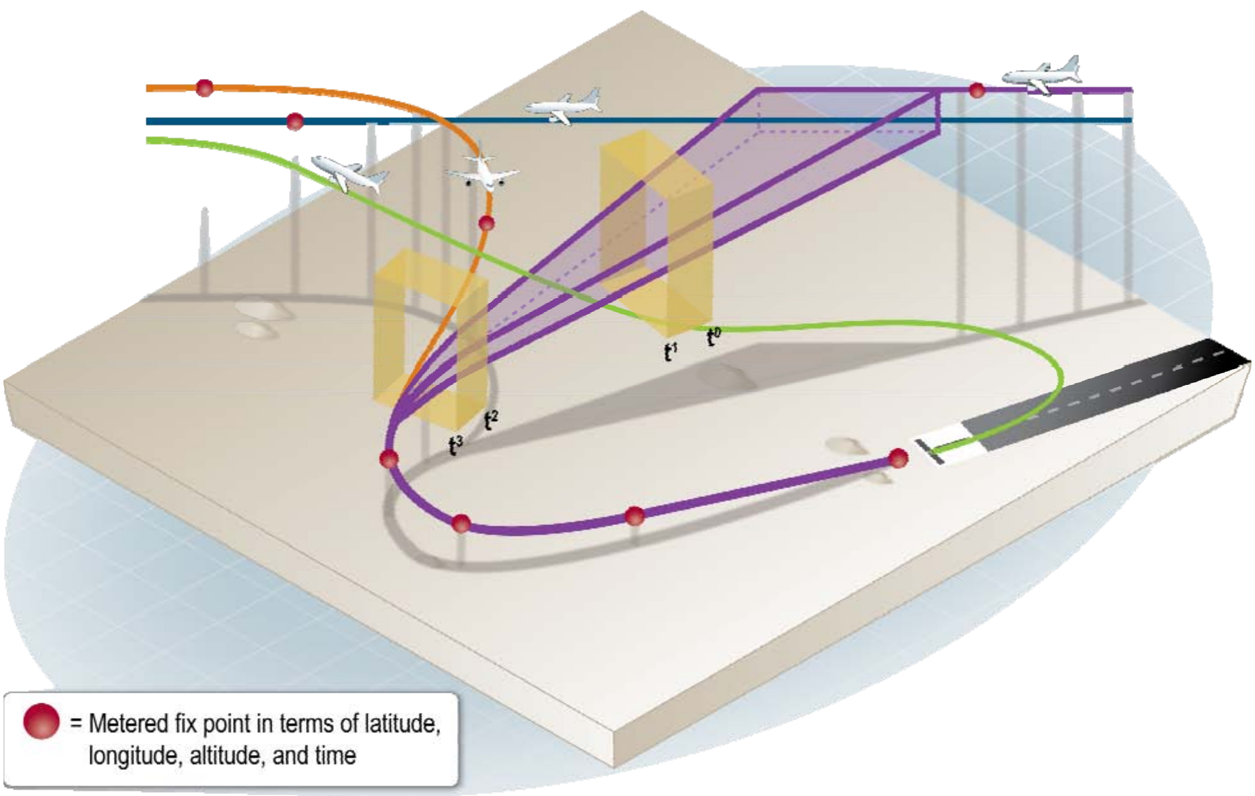
A 4DT is a precise description of an aircraft path in space and time: the “centerline” of a path plus the position uncertainty, using waypoints to describe specific steps along the path (See Figure 2-4). This path is Earth-referenced (i.e., specifying latitude and longitude), containing altitude descriptions and the time(s) the trajectory will be executed. The required level of specificity of the 4DT depends on the flight operating environment. Information regarding the operator’s flight plan is managed as part of the flight object.[5] The flight object provides access to all relevant information about a particular flight.

Some of the waypoints in a 4DT path may be associated with CTAs. CTAs are time “windows” for the aircraft to cross specific waypoints within a prescribed conformance tolerance and are

[5] The flight object is a software representation of the relevant information about a particular flight. The information in a flight object includes aircraft identity, CNS and related capabilities, flight performance parameters, flight crew capabilities including for separation procedures, and the flight plan (which may or may not be a 4DT), together with any alternatives being considered. [R-7] Once a flight is being executed, the flight plan in the flight object includes the “cleared” flight profile, plus any desired or proposed changes to the profile, and current aircraft position and near-term intent information (See Figure 2-6). For Visual Flight Rules (VFR) aircraft, the level of detail on the flight profile varies (e.g., it may consist of only information needed for Search and Rescue [SAR] operations). Allocation of responsibility for separation management along flight segments is also likely to be stored. International collaboration on the development of standards for the definition of a flight object is ongoing.

used when needed to regulate traffic flows entering congested en route or arrival/departure airspace. Both the flight crew and the ANSP may need to renegotiate CTAs during the flight for reasons such as winds encountered that are different than those forecast or a change in the destination airport acceptance rate. Much larger windows in time are allotted to cross all other waypoints not designated as CTAs, allowing operators more flexibility to optimize their flight operations.

Figure 2-4 Four-Dimensional Trajectory



One of the key concepts associated with TBO is the integration of trajectory planning and execution across the spectrum of time horizons, from strategic planning to tactical decision making. Strategic aspects of TBO include the planning and scheduling of flight operations and the corresponding planning and allocation of NextGen resources to meet demand, as described previously in Section 2.2.1. Tactical components of TBO include the evaluation and adjustment of individual trajectories to synchronize access to airspace system assets (or to restrict access, as required) and ensure separation, described in Section 2.3.1.

New ANSP personnel roles and supporting operations (Section 2.4.3) build on the use of TBO to provide ATM services. Air traffic services are provided through the generation, negotiation, communication, and management of both individual 4DTs and aggregate flows representing the trajectories of many aircraft. Flexible route definitions allow traffic flows to be shifted, as necessary, to enable more effective weather avoidance; meet environmental, defense, and security requirements; and manage demand into and out of the arrival/departure environment.

Capabilities for managing airspace structure include a common mechanism for implementing and disseminating information on the current airspace configuration to ensure that all aircraft meet the performance requirements for any airspace they enter. Similar information on airspace restricted for defense and homeland security ensures that these needs are met, maximizes access, and minimizes disruptions to commerce. Using automation to better manage uncertainties associated with weather minimizes airspace capacity limitations and reduces the likelihood of overly conservative actions. Different aircraft and flight crews also have varying levels of ability and preferences to operate in specific weather conditions. Individual flight limitations and preferences are key inputs to flight planning and execution, and flight operators may dynamically update these features. With this knowledge, the ANSP can support 4DTs tailored to individual flight preferences.

Within TBOs, some aircraft support additional operations via onboard capabilities and associated crew training, including the ability to perform delegated separation, airborne self-separation, and low-visibility approach procedures. Overall, these new kinds of flight operations dramatically improve en route productivity and capacity and are essential to achieving NextGen. Delegation of ATM functions to capable aircraft means these services are provided only when and where the aircraft need them, promoting scalability of the overall ATM system.

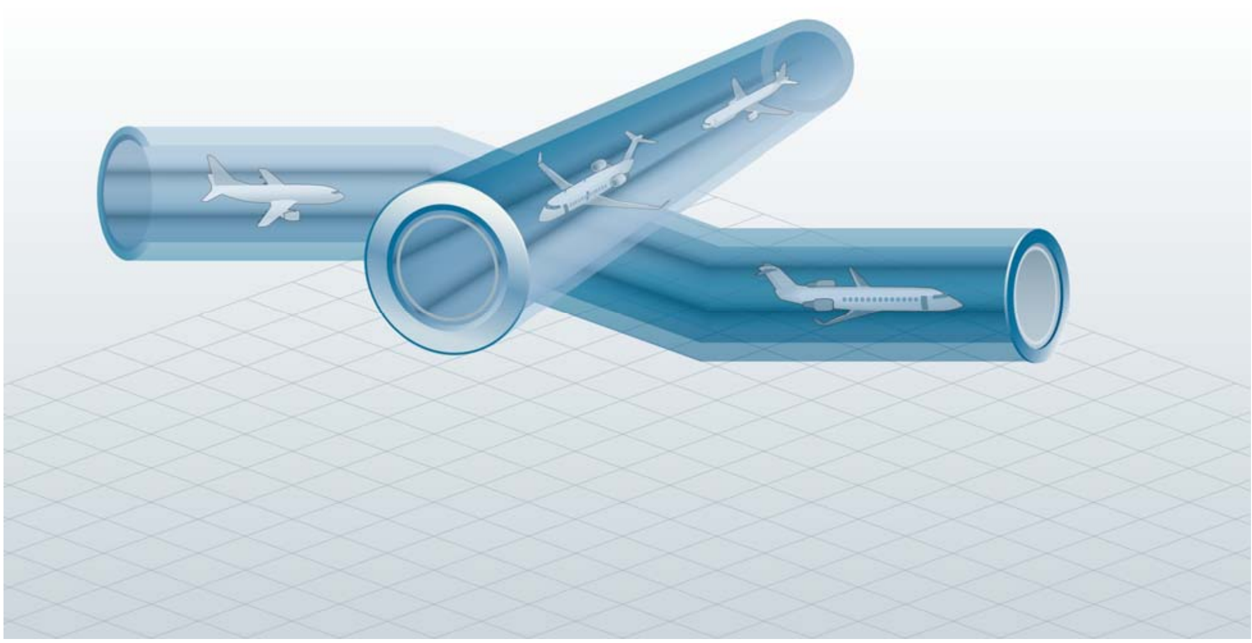
In the highest density arrival/departure areas, super-density arrival/departure operations are implemented to maximize airport throughput at times of peak demand while facilitating efficient arrival/departure profiles for equipped aircraft. Super-density arrival procedures are conducted, usually requiring airborne separation ability, and may be continued on the airport surface where required for throughput. Other arrival/departure areas with less demand, and high demand arrival/departure areas during off-peak hours, provide access to a wider range of aircraft. Aircraft routinely conduct low–noise approaches, mitigating noise impacts.

2.3.3.2 En Route and Cruise TBO

Operational distinctions between oceanic and en route airspace fade as performance-based operations and advanced CNS technologies become the norm. Some operational considerations remain for oceanic and remote airspace (e.g., when there are long distances between suitable landing locations). These operations accommodate aircraft equipped only for basic 4DT procedures, possibly along fairly structured routes when more capable aircraft are occupying the efficient routes and altitudes.

4DT procedures allow the ANSP to precisely schedule traffic through congested airspace, especially as aircraft start to converge approaching a major airport. When demand is very high, the ANSP may implement “flow corridors” for large numbers of separation-capable aircraft traveling in the same direction on very similar routes. (See Figure 2-5) Flow corridors consist of long tubes or “bundles” of near-parallel 4DT assignments, which consequently achieve a very high traffic throughput, while allowing traffic to shift as necessary to enable more effective weather avoidance, reduce congestion, and meet defense and security requirements. The airspace for aircraft operating in flow corridors is protected as aircraft not part of the flow do not penetrate the corridor.

Figure 2-5 Flow Corridors



The 4DT assignments in a flow corridor do not ensure that conflicts never occur, but do ensure that any conflicts are easily resolved with small speed or trajectory adjustments even with the high traffic density. The corridor is large enough for aircraft to use their separation capabilities for entering and leaving the corridors, as well as for overtaking, all of which are accomplished with well-defined procedures to ensure safety. Flow corridors are procedurally separated from other traffic not in the corridor. The high traffic density achieved increases the airspace available to other traffic and often eliminates the need for a TMI; thus the flow corridor is implemented along the optimum routes and altitudes. The corridor may be dynamically shifted to avoid severe weather or take advantage of favorable winds. Procedures exist to allow aircraft to safely exit the corridor in the event of a declared emergency.

For scalability and affordability, the ANSP delegates separation tasks to capable aircraft whenever this benefits the aircraft involved, overall operations, or ANSP productivity. Some airspace is designated as self-separation airspace where self-separation operations are required. En route trajectory-based procedures are summarized in Table 2-1.

Table 2-1 Summary of En Route and Oceanic Trajectory-Based Operations

Operation	Benefit	ANSP Ability	Aircraft Ability	Provision of Separation
ANSP-Managed Operations	High traffic density; accommodate wide range of aircraft capabilities	4DT exchange, including updates for SM, TM	Exchange and execute 4DT, CTA, RNP; some aircraft have delegated separation ability	ANSP via automation; or ANSP delegates to aircraft

Operation	Benefit	ANSP Ability	Aircraft Ability	Provision of Separation
Flow Corridors	Very high traffic density; preferred routing; ANSP productivity	4DT exchange with reduced requirement for updates, TM	Exchange and execute 4DT, CTA, RNP; delegated separation ability	Procedural separation of corridor from other airspace; aircraft within corridor separate themselves
Self-Separation Operations	Preferred routing; ANSP productivity	FCM, manage entry to/exit from self-separation airspace	Exchange and execute 4DT, CTA, RNP; full self-separation	Aircraft

2.3.3.3 Arrival/Departure TBO

Airspace, serving TB traffic, including aircraft arrivals and departures from complex and dense en route airspace is ANSP-managed with the TM and SM functions supported by advanced automation. Integrated arrival/departure area and airport surface management ensure that arrival flows match projected airport capacity for improved overall throughput and efficient flight trajectories that eliminate today's low–altitude path-stretching and holding. Aircraft are typically assigned final 4DT arrival profiles at the top of descent. The development of quieter aircraft, coupled with widespread implementation of low-noise approaches, eases restrictions currently imposed for noise abatement at many airports. Rotorcraft and other "runway-independent" aircraft needing access to trajectory-based arrival/ departure areas are coordinated with the major fixed-wing flows to avoid congestion and improve the overall flow of both types of aircraft. Table 2-2 presents arrival and departure procedures.

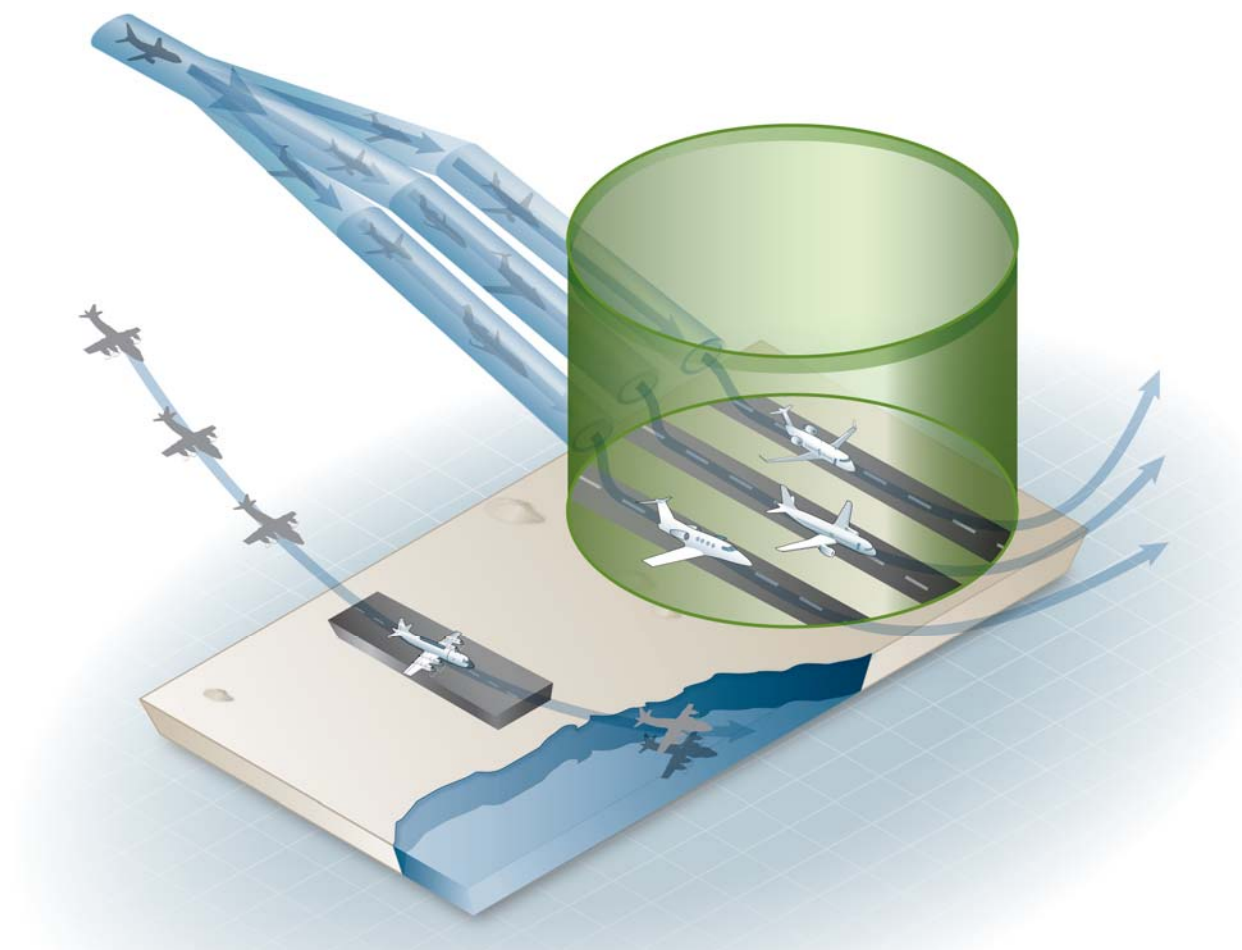
Table 2-2 Arrival and Departure Procedures

Operation	Benefit	ANSP Ability	Aircraft Ability	Provision of Separation
Optimized Profile Descent (OPD), other RNP trajectories	Reduced environmental effects; high throughput	4DT exchange, TM, SM	Exchange and execute 4DT, CTA, RNP, OPD; airborne spacing	ANSP automation
Merging and spacing	Arrivals matched to runway capacity, ANSP productivity	TM, 4DT exchange, SM	Exchange and execute 4DT, RNP; airborne spacing	ANSP automation
Closely spaced parallel approach (CSPA), paired approaches	Closely spaced runways maintain visual meteorological conditions (VMC) capacity in all visibility conditions	TM, 4DT exchange to establish aircraft on approach; SM wake vortex monitoring and automation	Exchange and execute 4DT, RNP; delegated separation	ANSP automation, except between aircraft conducting approach

At times of peak demand, major airports conduct super-density arrival/departure operations in which capacity-enhancing arrival and surface procedures are implemented to maximize runway throughput. Other airports with lower demand have fewer restrictive aircraft ability requirements, while some airports may serve aircraft of mixed equipage and capabilities depending on the airport configuration and level of demand.

Super-density operations may be required at more airports than today's Class B (39 busiest US airports) airports to handle the projected traffic increase. At times, super-density operations may restrict access to high-capability aircraft; however, they are only designated when warranted by demand and revert to accepting all trajectory-based traffic at other times of the day. As illustrated in Figure 2-6, super-density arrival/departure corridors handle arriving and departing traffic, while much of nearby airspace remains available to other traffic.

Figure 2-6 Super-Density Operations



Abilities used to achieve super-density arrival/departure operations are likely to include the procedures listed in Table 2-2 above and the following:

- Use of RNP operations
- Use of procedures that eliminate requirements for visual operations
- Mitigation of wake vortex constraints through detection and real-time adaptation of applied separations
- Improved runway incursion prevention procedures and technologies
- Automatic distribution of runway braking action reports
- Distribution of taxi instructions before landing that can be automatically executed without waiting for a separate clearance

2.3.3.4 Surface and Tower Operations

Surface operations in the NextGen time frame at medium- and large-demand airports are integrated with other ATM functions, including departures, arrivals, and collaborative traffic management. Improved surveillance, automation, and information sharing enhance surface and tower operations for all traffic. The busiest airports, at peak times (most likely those implementing super-density arrival/departure operations), conduct super-density surface operations for adequately equipped traffic to maximize runway throughput and minimize taxi times while moving aircraft safely and with robust runway incursion prevention. Air traffic control towers provide enhanced services compared to today. Particularly in low-visibility conditions, the ANSP can safely make more efficient use of runways through real-time depiction in the tower of the location and intent of arriving and departing aircraft, as well as any aircraft intending to cross an active runway. For lower-demand airports, staffed or automated virtual towers may be implemented to provide tower services equivalent to those of traditional towers. This allows tower services to be provided at more airports than is affordable today and/or for extended hours of service. Table 2-3 provides a summary of NextGen surface transformations.

Table 2-3 NextGen Surface Operation Transformations

Current Roles	Corresponding NextGen Roles
Ground surveillance available to ANSP limited. Primary and some secondary surveillance abilities are installed, providing conflict resolution and information, but limited to Operational Evolution Partnership airports. Runway incursion prevention automation is also limited	Cooperative ground surveillance at most airports, including state vector information (e.g., aircraft speed/direction), with more effective runway incursion prevention automation
Essentially no cockpit surveillance of other ground traffic/vehicles, other than visual (out the window)	Integrated surveillance of ground traffic, along with airport layout and taxi routes, with cockpit warning of runway incursions

Current Roles	Corresponding NextGen Roles
Surface movement information (e.g., pushback, departures, taxi delays) mostly not integrated with Traffic Flow Management (TFM). Difficult to implement flight-specific TMIs	Updated pushback information provides improved surface and departure management. Surveillance of surface movement provides basis for more accurate departure time and taxi delay estimates. Availability of improved departure time estimates significantly improves ability of FCM and TM. Flight-specific TMIs are handled via automation and data communications.
Many non-towered airports	Automated NextGen Towers (ANT) or better where economically feasible
Inefficient one-in-one-out operations at smaller airports without approach controls or towers	Elimination of one-in-one-out restrictions at most airports for equipped aircraft

2.4 TRANSFORMED ROLES AND RESPONSIBILITIES

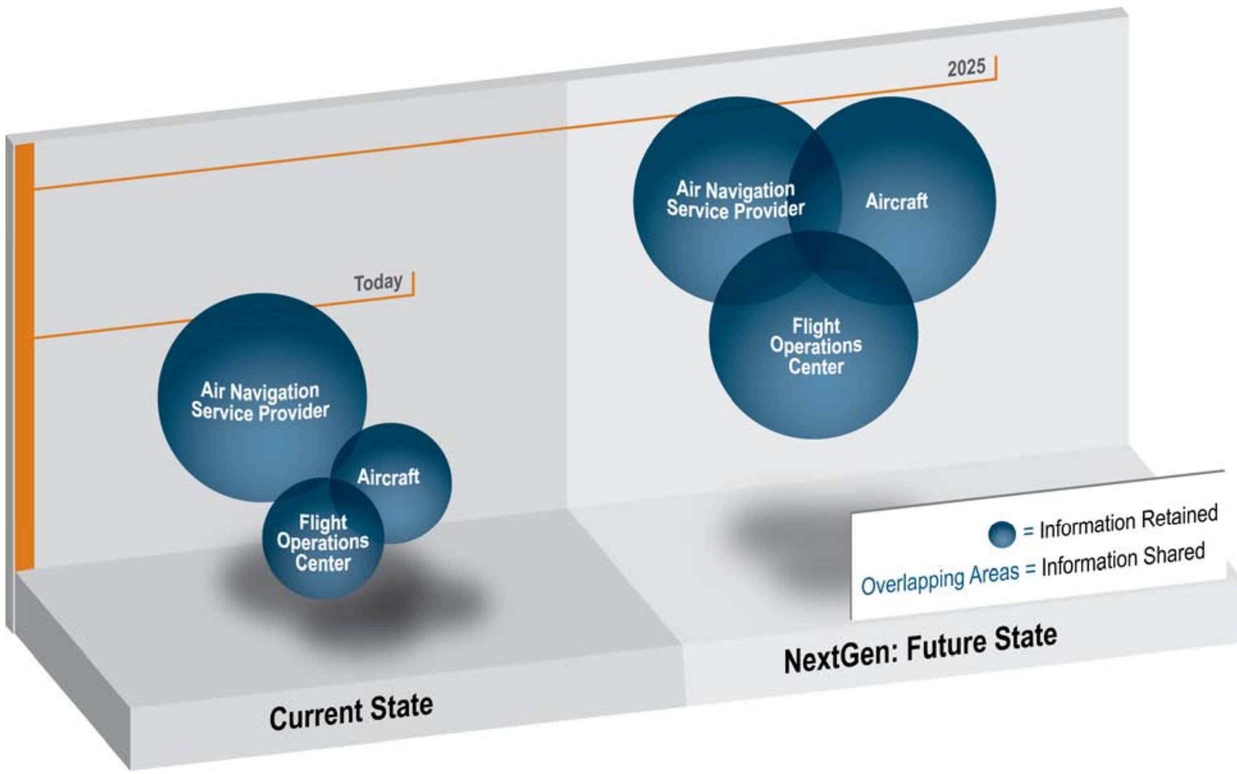
With the increase in demand, anticipated in the next 10 to15 years, and the subsequent increase in complexity of operations, the NextGen environment requires changes in roles for ANSP personnel and flight operators. New tasks are performed by automation to support the decision-making process, and the shift in focus moves from tactical separation between individual aircraft to the strategic management of traffic flows in high-density airspace. Flight operator roles change accordingly. As illustrated in Figure 2-7, decision making is more distributed among ANSP personnel, flight crews, and flight planners, with a significant increase of information exchange. Flight planners have an increased role in collaborating with the ANSP on capacity and flow management strategies, and the flight crew has a greater role in many of the tactical flight management tasks. For some aircraft, the flight crew also begins to take on a more strategic flight management role, building on aircraft automation.

Today's NAS, in which controllers provide safe aircraft separation by issuing tactical clearances for individual aircraft, is reaching its capacity as splitting sectors further produces diminishing benefits. A new paradigm is required to better manage human workload, increase productivity, and leverage advanced automation capabilities. This, in turn, requires transformation to achieve NextGen scalability and affordability goals, including the following:

- Restructuring the roles of humans and automation and how they perform their respective functions to synergize human and automation performance
- Better distribution of tasks and decision making between service providers, flight crews, and flight planners to achieve operational efficiencies and scalability
- Broadening the resource pool of service providers by eliminating the "hard-wired" connection between service providers and geographic regions (Chapter 4)

These transformations are discussed in further detail in the following subsections.

Figure 2-7 Relative Influence of the ANSP and Aircraft/Pilot in ATM Decisions



2.4.1 Functional Task Allocation

The NextGen ATM system capitalizes on human and automation capabilities. It employs complementary air and ground technologies in a distributed manner. Both humans and automation play important and well-defined roles, which take advantage of the types of functions each can best perform. Although new technology is critical to implementing the NextGen ATM system, equally critical is ensuring that both service providers and flight operators are given appropriate roles as discussed in Sections 2.4.3.1 and 2.4.4.

Automation supports the migration from tactical to strategic decision making by assimilating data and supplying information as well as by performing many routine tasks. Ultimately, the determination of when to fully automate and when to provide decision support is made to optimize overall system performance and ensure that service providers and flight operators perform well and can respond to off-nominal and emergency events when required.

Increased reliance on automation is coupled with "fail-safe" modes that do not require full reliance on humans as a backup for automation failures. In addition, backup functions are distributed throughout the system, and there are layers of protection to allow for graceful degradation of services in the event of automation failures.

2.4.2 Human-to-System Interactions

Human-to-system interactions are designed to gain safety, productivity, efficiency, and scalability benefits. Human factors considerations are paramount to maximizing ANSP productivity and performance and are integrated into system acquisition management and planning. Human factors considerations that drive human-to-system design and impact human-to-system performance include human cognitive capabilities and limitations, human error, situational awareness, workload, function allocation, hardware and software design, procedural design, decision aids, visual aids, training, user manuals, warnings and alarms, environmental constraints, workspace design, and team versus individual performance.

Within NextGen, human interactions with automation are more intuitive and user-friendly, allowing increased utility of tools while mitigating human error. New tools, measures, and mechanisms are in place to preclude and mitigate the effects of human error, with error tolerance and error resistance achieved through human-centered design processes. Service providers and flight operators are presented with well-integrated user interfaces. Flight deck systems are easier to use and better integrate information for situational awareness and decision making. Likewise, ground automation systems seamlessly integrate decision aides such as automated conflict detection and resolution.

2.4.3 Flight Operator Roles and Vehicle Types

There is a wide diversity of flight operations and flight operators in NextGen. Flight operators, the primary users of ATM services, have a range of objectives for operating flights, depending on their business models. Examples of flight operators and their objectives include the following:

- **Scheduled Operators.** The primary objectives associated with scheduled operations are maintaining schedule integrity and operating efficiency. For many operators, the ability for NextGen to accommodate growth in schedules is also important.
- **On-Demand Operators.** The objectives for on-demand operators include continual and equitable access to NextGen resources and operating efficiency.
- **Corporate Operators.** Corporations operating aircraft to support their core (not necessarily aviation) business need access to airports and airspace for the conduct of commerce.
- **State and Military Aircraft Operators.** State and military operators require access to all areas of NextGen and may, at certain times, require NextGen to accommodate aircraft that do not meet all expected capability and performance requirements. These operators may also require priority access to complete a specific mission or objective. Military aircraft operators require the ability to operate in areas designated for their special use to conduct training and proficiency operations.
- **Space Vehicle Operators**. Routine access to space requires space vehicle operators to operate through the NAS on the way to and from space, according to schedules that are known well in advance.

The term “flight operator” is used broadly to cover all people or organizations that operate aircraft, including scheduled, on-demand, personal aircraft, and state and military aircraft operators, and emerging flight operations such as unmanned aircraft and space vehicles. The common theme for this diversity of ATM customers is their transformed ability with NextGen to achieve their business and operational objectives through access to reliable real-time information relevant to their proposed operation, to understand the impact of their decisions related to their operations, and to negotiate with the ANSP to achieve their objectives. Many operators have advanced capabilities that are complementary to the ANSP and can take advantage of the significant opportunities for access, efficiency, and predictability afforded by NextGen. These transformed operations provide benefits for any operator that invests in the needed ability, whether general aviation, commercial, civil, or military. The adoption of performance standards rather than equipment standards encourages innovation by avionics suppliers to produce affordable capabilities supporting trajectory-based procedures and real-time flight information (e.g., weather, airspace configuration, and traffic) in the cockpit.

Benefits desired by flight operators include maintaining schedule integrity, operating efficiently, having access to airspace and airports in the presence of congestion, operating with minimal disruption from weather or visibility, having increased safety and utility, suffering minimal disruptions from security and defense operations, and having reduced operating costs. State and defense providers also have unique needs for access to airspace, including transiting through airspace to complete missions or for training. In addition, a broad community of operators, who fly under VFR, continue to want access to airspace.

Flight operators have a wide range of capabilities and options to meet their mission needs. The minimum ability for operating in any managed airspace is cooperative surveillance, the ability to perform RNAV operations (if operating under instrument flight rules [IFR]), and communication with the ANSP via voice radio. In airspace where HP-TBO is used (Section 2.3), the minimum ability includes the ability to conduct RNP operations combined with the exchange (via a digital data link) and execution of precision 4DTs. Digital data communications between flight operators and the ANSP are the norm performed in HP-TBO airspace; voice radio is used on exception and as a backup. Some airspace requires the ability to perform delegated or self-separation operations in addition to the above. Many aircraft in NextGen are capable of digital data communications to communicate with the ANSP (for clearances, requests, and aeronautical information) to send and receive weather information and to receive surface movement instructions. Many operators also are able to communicate between aircraft and their FOC for exchanging flight planning and trajectory information, aircraft performance and maintenance data, flight following information, and passenger-related information. Flight planning systems also have a range of capabilities, including the ability to exchange and negotiate information supporting the C-ATM process.

Each operator makes choices, based on his or her own business model, about the desired operations and the tradeoffs between increased levels of service from the ANSP versus the needed investment in flight planning and aircraft capabilities and performance. As operations grow in level and complexity, operators continue to make choices on whether to invest in needed capabilities and training, if additional procedures are required to operate.

2.4.3.1 Flight Operator Roles

Flight operator roles during flight planning and flight execution vary based on flight operator capabilities and are highlighted in Table 2-4. Other flight operator roles such as marketing and strategy development are outside the scope of this document.

Table 2-4 Flight Operator Roles

Current Roles	Corresponding NextGen Roles
Dispatcher/FOC Personnel Responsible for originating and disseminating flight information, including flight plans. Responsible for operational control of day-to-day flight operations. Also responsible for understanding weather and other constraints, incorporating these into flight plans, and in some organizations, coordinating with ANSP personnel regarding overall flow issues. General aviation operators also may interact with third-party (fee-for-service) vendors who provide weather and other services (e.g., flight planning) through dedicated computer terminals, direct phone contact, or the Web.	**Flight Planner** Responsible for making tactical decisions about what flights to operate and when and where they operate. May be the same as flight crew. Is the interface with the ANSP C-ATM function to develop collaborative capacity and traffic flow management decisions and in trajectory negotiation. Operators with multiple aircraft involved in the initiative have the flexibility to adjust individual aircraft schedules and trajectories within those allocations to accommodate their own internal business concerns, both preflight and in flight.
Flight Crew Responsible for the control of an individual aircraft while it is moving on the surface or airborne.	**Flight Crew** Responsible for the control of an individual aircraft while it is moving on the surface or airborne. Under delegated operations, responsible for separation. May comprise a single pilot or multiple individuals (e.g., two pilots). For Unmanned Aircraft Systems (UAS) systems, may operate the aircraft remotely; for “autonomous” UAS (programmed with an overall mission), may be an automata.

For flight execution, there is a transition from pilot to aircraft systems manager for all classes of pilots as aircraft capabilities evolve. The roles of the flight crew for advanced aircraft in NextGen include aircraft system manager, supervisory override, and participant in the C-ATM function. When separation is delegated, the flight crew assumes the role of separation manager as well. For aircraft not equipped with TBO-enabling technology, the flight crew operates much as today, including those operating under VFR. In the supervisory override role, the flight crew is responsible for operating the aircraft and taking any actions deemed necessary to correct system malfunctions that occur during flight. During surface operations, the flight crew has full control of the aircraft and is responsible for maneuvering it and determining if it is fully functional before takeoff. For some aircraft, flight management automation may be used for surface operations as well.

2.4.3.2 State and Military Operations

Many state aircraft—primarily those operated by the military—require transition between seamless operations among civil aircraft and exceptional flight requirements (e.g., needing special services from the ANSP or departing airspace managed by the ANSP) during a single flight. The initial phases of the mission operate in similar fashion to those of civil users until aerial refueling (AR) operations are initiated. At that point, the operation becomes unique and remains so until the AR mission is accomplished. After the AR mission is complete, the aircraft is re-integrated into normal NAS operations.

2.4.3.3 Unmanned Aircraft Systems

UAS operations are some of the most demanding operations in NextGen. UAS operations include scheduled and on-demand flights for a variety of civil, military, and state missions.

UASs are managed by 4DT procedures (Section 2.3); however, because of the range of operational uses, UAS operators may require access to all NextGen airspace. The UAS operators must be capable of conducting the procedures required for the airspace and must achieve the same target level of safety against collisions as manned aircraft. Because UASs may also operate in airspace in which cooperative surveillance may not be required, they have the responsibility for sensing and avoiding other aircraft. This may include responsibility, in some airspace, for separating from aircraft that do not have cooperative surveillance.

2.4.3.4 Vertical Flight

Rotorcraft, tiltrotor, vertical/short takeoff and landing (V/STOL), and similar aircraft have different flight capabilities and limitations from fixed-wing aircraft, and they often perform unique and demanding missions.

Transport category IFR-capable rotorcraft are being acquired in larger numbers. With growing ground congestion, these aircraft have increased utilization. In addition to civil uses, rotorcraft continue to have an increasing role in homeland security and other missions. They provide emergency medical services in all areas of the United States and increasingly perform IMC operations. Rotorcraft are also used for UAS applications for commercial, police, and security operations. These operations add to the density and complexity of operations, particularly in and around urban areas.

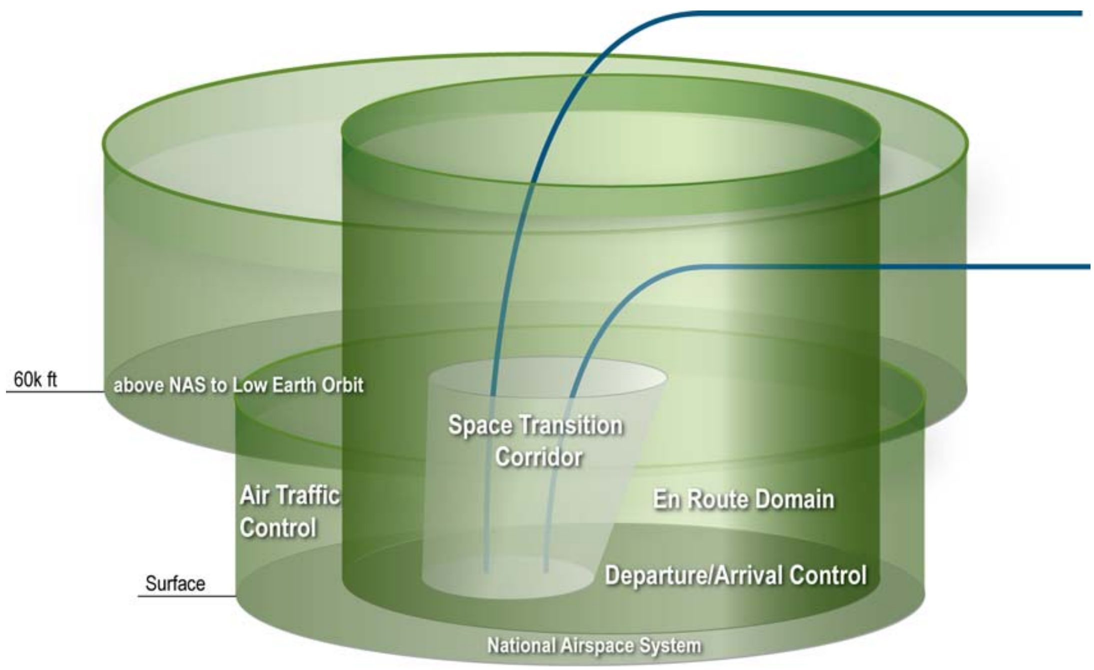
2.4.3.5 Trans-Atmospheric and Space Operations

Some aircraft are destined for specific mission operations at flight level 600 and above. These “near-space” and space operations continue and expand in diversity in the NextGen time frame. Near-space and space aircraft exhibit a wide variance in capability and vehicle performance (e.g., aerostats, medium- and high-speed research/reconnaissance aircraft, suborbital spacecraft, launching and reentering orbital spacecraft). Some users of this airspace are expected to have unique needs that can be accommodated only with security restricted airspace-equivalent to today’s temporary flight restrictions.

In the future operational environment, ANSP facilities will be responsible for maintaining the safe and efficient flow of both air traffic and space traffic within the NAS. ANSP facilities work

with spaceports and space traffic management, as illustrated in Figure 2-8, to ensure safe and efficient operations within the NAS and NextGen, as spaceflight vehicles depart and return on their way to or from space. ANSP facilities have the authority to impose airspace restrictions, reroute air traffic, instruct spaceports to hold spaceflight vehicles on the ground, or (in emergency situations) divert flight vehicles to alternate destinations, as means of accommodating spaceflight vehicle departure and return operations through the NAS.

Figure 2-8 Space Operations in the NextGen NAS[6]



2.4.4 Transformations in ANSP Processes

ANSP service delivery mechanisms are transformed to provide ATM services in a safer, more secure, scalable, and affordable manner. Processes are revolutionized, from the way ANSP personnel are trained and allocated to airspace to the way long-term capacity changes are managed. The changes in ANSP processes and personnel management are geared toward the following goals:

- Managing resources dynamically to enable the ATM system to apply people where their services are most needed
- Managing and configuring facilities (including airports) appropriately
- Designing airspace and designating its use to complement operations
- Ensuring that the ATM system is globally harmonized through collaborative development and implementation of identified best practices in both standards and procedures

[6] FAA, Space Vehicles Operators Concept of Operations, 2008.

- Ensuring that safety, security, and environmental considerations are fully integrated into ATM

Within the ANSP workforce, the emphasis in NextGen is on strategic flow management and collaboration with airspace users. Flow contingency managers monitor and assess capacity requirements for flows of traffic. With DSTs, they determine optimum flow and airspace configurations in collaboration with capacity managers and through collaboration with flight operators and other stakeholders. Separation managers and trajectory managers interact to determine optimum system solutions and implement decisions strategically. A broad set of strategic ANSP functions include the following:

- Forecasting demand to support effective and timely capacity planning
- Managing capacity, including dynamic management of NAS resources
- Collaborating with airspace users on flow management strategies
- Managing trajectory and negotiating with flight operators, if needed
- Maintaining the flight object and providing flight planning support
- Providing flow strategy and trajectory impact analysis services
- Maintaining the net-centric infrastructure and providing other NAS infrastructure services (e.g., navigation and surveillance)
- Coordinating changes to U.S. and international procedures

Some of these functions are new in NextGen; many are enhanced. Existing functions (e.g., forecasting demand, providing navigation and surveillance services) are also transformed. The transformations are discussed in subsequent chapters. In addition, although flight planning and weather services are automatically disseminated or provided by third-party service providers, ANSP personnel still provide safety-critical, in-flight services. Table 2-5 defines the NextGen service provider roles in relation to those of current service providers.

Table 2-5 Air Navigation Service Provider Personnel Roles

Current Roles	Corresponding NextGen Roles
Area Supervisors, Airspace Designers Design and strategically allocate airspace. Adjust the assignment of airspace to tactical separation providers (primarily by combining and de-combining sectors). Structure routings (air and ground) where required.	**Capacity Managers in Collaboration with Airspace Users and Flight Operators** Design and strategically allocate airspace. Dynamically adjust the assignment of airspace to tactical separation providers. Structure routings (air and ground) where required, and flexibly allocate airspace for other purposes, including the operation of state (government) aircraft.

Current Roles	Corresponding NextGen Roles
Traffic Management Specialists/ Coordinators Identify potential flow problems, such as large-demand capacity imbalances, congestion, high degrees of complexity, and blocked or constrained airspace (e.g., for special use, weather), and collaborate on traffic management initiatives	**Flow Contingency Providers in Collaboration with Flight Operators** Identify potential flow problems, such as large-demand capacity imbalances, congestion, high degrees of complexity, and blocked or constrained airspace (e.g., for special use, weather), and collaborate to develop flow strategies (i.e., aggregate trajectory solutions)
Traffic Management Specialists/ Coordinators, Air Traffic Controllers Ensure that TMIs are carried out. Perform planning for flights entering sector, identify future conflicts (i.e., strategic SM), and coordinate resolutions with adjacent sectors	**Trajectory Managers in Collaboration with Flight Operators** Predict individual flight contention within a flow for resources, identify complex future conflicts (i.e., strategic SM), and coordinate individual trajectory resolutions. This is focused on near-tactical management of individual trajectories within a flow
Air Traffic Controllers Provide tactical separation to separate aircraft from other aircraft and SUA, and organize and expedite the flow of traffic	**Separation Managers (May Be Flight Crew Depending on the Airspace and the Operation)** Eliminate residual conflicts left by the three strategic functions of TBO. Automation detects the conflicts and provides the resolution
Flight Service, Third-Party Service Providers Provide flight planning and weather services (e.g., Direct User Access Terminal [DUAT])	**Automated Dissemination to Operators and Flight Crews, FOCs, Third-Party Service Providers** Provide flight planning support and weather services. ANSP role is limited to safety-critical in-flight assistance. Operators may also interact with third-party weather providers or their own FOC

Because NextGen transformations significantly change the roles and responsibilities of ANSP personnel, substantive and organic changes in ANSP personnel management are necessary. NextGen transformations with the largest impact include:

- TBO and airspace
- Performance-based separation standards
- Greater levels of coordination between aircraft and flight crew in operations
- Reliance on intelligent automation, including for tactical SM
- Emphasis on strategic flow management to minimize the need for tactical separation maneuvers
- Dynamic assignment of airspace boundaries and associated NextGen operations

These operational transformations require corresponding transformations in ANSP personnel selection, staffing, training policies, and practices to meet NextGen performance objectives (Table 2-6). Considerations include:

- Personnel selection (e.g., minimum skill levels, special skills, experience levels, cultural issues)
- Staffing (e.g., staffing levels, team composition, job design, team communication, organizational structure)
- Training (e.g., training regimen, training effectiveness, skill retention and decay, retraining, emergency operations training, training devices and facilities, embedded training)

Table 2-6 Personnel Management Transformations

Significant Transformation	2006 Current	2025 NextGen
Personnel Skills and Selection	• Tactical (sector) controllers dominate ATC workforce. • Controllers must learn local characteristics of airspace. • Skill sets are matched to traffic characteristics within airspace (e.g., high-altitude cruise, transition, terminal).	• Separation managers are assigned only to aircraft not equipped to a sufficient level of HP-TBO-enabling technology for a given operation. Common airspace/flow configurations, DSSs, and a net-centric information management system minimize the need for local airspace knowledge. • Skill sets are matched to traffic characteristics in airspace.
Flexible Staffing	• Controllers are assigned to one area of specialty within a facility. • Sectors are combined/de-combined to manage workload. • Constant adjustments are made to facility staffing levels to match traffic levels; facility grade is assigned by traffic levels.	• ANSP personnel are assigned in and across facility boundaries to match staffing to traffic demand. • Airspace assignments change dynamically. • Different operational grade levels exist within a general service delivery point to support career progression.
Training	• Facility training is the longest part of training to learn local characteristics of airspace. • Training emphasizes tactical separation in a variety of conditions and traffic loads.	• Commonly configured airspace reduces facility training time from months to weeks or days. • Training emphasizes management of off-nominal operations.

ANSP service delivery is performed through a combination of new procedures, technologies, and infrastructure, significantly increasing safety, security, and capacity of air traffic operations in the NAS. ANSPs will require different automation, procedures, and skill sets than those that are

utilized in today's ATC environment. The requirement for the service provider to retain local knowledge of the airspace (e.g., frequencies, airspace fixes, and handoff procedures) is minimized; therefore, the airspace can be treated like commonly configured airspace. This is particularly true at high altitudes. Commonly-configured airspace affords great flexibility in the airspace and corresponding traffic to which ANSP personnel can be assigned and in the frequency with which the assignments can dynamically change. It also enables the reclassification of ANSP personnel commensurate with the new types of operations. Direct-addressable communication reduces the requirement for frequency management and knowledge. Currently in airspace where ANSP personnel provide tactical separation and all aircraft capabilities must be accommodated, the skill set of the ANSP personnel is similar to that of a radar controller.

New ways of staffing air traffic facilities take advantage of available resources and provide additional opportunities for career growth. Automated staffing tools help facility managers match staffing to traffic demand, so that management of NAS resources is dynamic and flexible enough to adjust to changes in the market as well as changes to daily and seasonal traffic flow. Ebbs and flows in traffic levels can be efficiently managed, unconstrained by facility boundaries, with the necessary communication, data, and surveillance capabilities. By decoupling geographic airspace and infrastructure constraints from aircraft operations, capacity managers have the flexibility to leverage resources across facilities to match staffing to traffic demand.

Co-locating operational domains (e.g., tower control and terminal airspace, approach control and en route airspace) of differing complexity levels into general service delivery points allows service providers to advance to higher grade levels without having to relocate. This has the dual benefit of providing employees better opportunities for career progression while dramatically decreasing operating, maintenance, infrastructure, and permanent-change-of-station costs.

All air traffic facilities benefit from scheduling and workforce management improvements. Staffed NextGen Towers (SNT) allow ANSP personnel to service multiple airfields from a single physical location. The ability to use SNTs enables airports to receive tower services that they normally do not receive, given the criteria of today and the costs of building a tower. In addition, Automated NextGen Towers (ANT) are an innovative, affordable way to provide new services where service delivery was not practical before. ANTs are beneficial for smaller, towered airports or SNT airports, as they continue providing existing services during off-hours at reduced staffing costs. A voice interface ensures that aircraft without data communication equipage can receive service.

Commonly configured airspace significantly reduces the time required to achieve various levels of ANSP personnel certification from months to weeks or days. Reduced training time is in part enabled by the elimination of inter-facility letters of agreement and the corresponding need to learn all local characteristics of the airspace. This in turn reduces training costs and fosters other benefits such as increased flexibility in scheduling, more rapid response to staffing needs, and reduced stress on training resources (e.g., on-the-job training instructors).

Various levels of fidelity in training simulators reduce training cost and time. The enhanced process and inherent simulation capabilities provide for more standardized instruction, unbiased assessment of performance, mitigation of weaknesses, and useful remedial and proficiency

training. Performance measurement tools evaluate the efficiency and efficacy of training programs, processes, and paradigms on the development and enhancement of skills performance. They also measure job performance competencies and related knowledge, skills, and abilities that determine individual and team safety, efficiency, and effectiveness.

Some members of the NextGen workforce are hired into the new roles of ANSP personnel (e.g., CM, FCM, TM), while others are retrained from the classic roles of air traffic controller and traffic flow manager. Given NextGen's reliance on automation, ANSP personnel are selected and trained to ensure that they can deliver the essential services when off-nominal or emergency conditions exist. This necessitates that a significant portion of the training focuses on dealing with emergencies and exceptional situations in addition to all other necessary skills to support NextGen. This in turn necessitates not only that systems have a very high level of reliability but also that failures are controlled in a gradual degradation, providing ample time to reduce traffic to the reduced capacity levels.

Selection criteria tailored to the type of ATM services provided (e.g., tower controller, traffic flow manager), innovative and flexible staffing techniques, and a revamped training program ensure that the ANSP workforce is best prepared to meet the demands and challenges of NextGen.

3 Airport Operations and Infrastructure Services

3.1 INTRODUCTION

As a central link in the air transportation chain of operations, airports are a determining factor in the total capacity of the air transportation system. Accordingly, airports are critical to the overall transformation to the Next Generation Air Transportation System (NextGen). Airports serve as the integrative space between ground and air transportation systems. They enable aircraft to arrive and depart in a safe, efficient, and secure manner, while also facilitating the movement of people and cargo, on and off aircraft.

Achieving the capacity growth needed to meet future demand for aircraft operations and passenger and cargo movements at airports will be a significant challenge. NextGen seeks substantial improvements in the utilization of existing infrastructure as well as the development of new infrastructure at both scheduled air transport service and general aviation airports to benefit the passenger, cargo, and general aviation aircraft operators that use the nation's airports.

Unlike other components of the air transportation system that are directly managed by the federal government, airport decisions are primarily made at the local level. The development or transformation of an airport hinges on the efforts and decisions of the communities and users that it serves. The factors that drive many airport investment decisions are primarily market- and user-driven, rather than falling under the jurisdiction of the federal government. Even as airports seek to be responsive to the needs of the aircraft operators and traveling public, these particular users are responding to market factors. Factors that are expected to drive airport development and operations through 2025 and beyond include the following:

- Significant capacity gains can be achieved from maximizing the use of existing infrastructure, increasing the utilization of general aviation and reliever airports, and implementing new air traffic management (ATM) procedures that increase airport efficiency. Additional capacity gains may also be achieved by developing new infrastructure at scheduled air transport service and general aviation airports.

- Some scheduled air transport service hub airports that are approaching capacity today may not be able to reasonably expand to support unconstrained demand in aircraft operations or passenger movements. In these cases, the re-development of other existing airports in the congested area may be necessary to augment regional capacity.

- People and cargo will need to get to and from the airport in a predictable and efficient manner. Therefore, efficient intermodal transportation networks and information systems will be needed to link airports with population and business centers.

- Collaboration among federal, state, and local agencies is needed to support the effective governance of NextGen airport operations and regional considerations, given the many stakeholders who have vital interests in a successful airport system.

In recognition of these drivers, the concepts described in the following sections provide available services that airports can adopt, as dictated by their needs and missions—there are no “one size fits all” solutions for airports. For example, the busiest scheduled air transport service hub airports may need systems to actively manage ramp operations to reduce congestion; however, a small hub airport is not likely to have sufficient ramp congestion to warrant this investment. Some scheduled air transport service hub airports that cannot easily expand their terminal buildings may have a need for off-airport passenger processing capabilities, while other airports will choose to build expansive, flexible terminals. General aviation and reliever airports may seek facility improvements and instrument approach access that will serve the needs of their general aviation aircraft operators. Following the tradition of airport development in the United States, the actual implementation of these concepts will be done through local decision making in cooperation with the airport operator, users, and neighboring communities, along with support from local, state, and federal governments.

As shown below, the NextGen Provide Flexible Airport Facility and Ramp Operations capability will enable airside, landside, and terminal airport infrastructure to be balanced in order to achieve optimal use of total airport capacity. Future growth in aircraft operations cannot be accommodated without application of innovative ATM technologies and procedures, construction of additional infrastructure at major airports, and/or better utilization of existing infrastructure at supporting airports.[7] NextGen seeks to increase the overall capacity of the existing airport system through the implementation of transformational concepts that enable the optimum and balanced utilization of airside and landside (i.e., terminal and intermodal transportation) components at national, regional, and local levels. The growth of the airport system will incorporate factors for environmental, financial, and regional sustainability.

Provide Flexible Airport Facility and Ramp Operations: Flexible airport facility and ramp operations provide the ability to reallocate or reconfigure the airport facility and ramp assets to maintain acceptable levels of service that will accommodate increasing passenger and cargo demand levels, or changes in operational requirements, through infrastructure development, predictive analyses, and improvements to technology (e.g., automation and decision support systems) and procedures.

This chapter focuses on NextGen airport concepts and capabilities needed to improve airport operations that are distinct from surface ATM concepts and capabilities. Advanced ATM procedures and technologies will improve the operational capacity of existing airport runways and the efficiency of surface operations. This includes, for example, performance-based navigation to provide Visual Flight Rules-equivalent operations during Instrument

[7] Supporting airports include small hub, non-hub, and non-primary commercial service and general aviation airports in congested metropolitan areas.

Meteorological Conditions on closely spaced parallel runways. On the airport surface, synthetic vision, moving maps, and automated alert and de-confliction systems will provide safe navigation of aircraft and ground support equipment (GSE) during low-visibility conditions. Additional information on ATM capabilities is provided previously in Chapter 2.

3.2 TRANSFORMED AIRSIDE OPERATIONS

Efficient operations of aircraft and vehicles on the airport surface will be important for maintaining the smooth flow of operations envisioned with NextGen. Given the high numbers of aircraft operations that are projected to occur at the busiest airports in the future, airport ramp areas will become more complex and crowded. NextGen incorporates concepts to facilitate the orderly flow of GSE and maintain safety on airport ramps. In addition, the active management of ramp operations is needed to mitigate ground congestion during inclement weather events because weather can substantially and frequently impact airport operations. For example, winter weather impacts runway availability; freezing rain and snow require de-icing of aircraft; lightning halts ramp operations; and low visibility affects the mobility of GSE; however, these impacts can be significantly reduced by integrating weather information directly into decision making. Therefore, an important objective of NextGen is to reduce the impact of weather on airside operations.

3.2.1 Coordinated Ramp Operations Management

The movement of aircraft and GSE on the airport surface requires new logistics, management, and technology in order to enable the efficiencies required with NextGen.

Surface movements of GSE are monitored via cooperative and non-cooperative surveillance in real time, with proactive management using net-centric infrastructure to ensure the smooth, efficient, and safe flow of vehicular traffic such as baggage carts, fuel trucks, catering vehicles, and other airport vehicles. GSE has equipment to ensure accurate navigation during low-visibility conditions, maintain clearance from active runway and taxiways, and separation from aircraft.

GSE has defined operating areas on the ramp specific to its function. This aids in providing separation from aircraft and supporting security protocols. At some airports, subterranean conveyors and fuel hydrant systems may also be employed to reduce ramp congestion and improve safety. Ground-based perimeter sensors ensure that aircraft can be maneuvered on the ramp without coming into contact with other aircraft, GSE, or obstructions.

Congestion is reduced while improving level of service, environmental benefits, and safety. GSE requirements for surveillance and communications requirements are compatible with ATM surface traffic management systems and decision support systems. Real-time surface surveillance of aircraft and GSE is available for all airport stakeholders, including the airport operator, aircraft operators, Security Service Provider (SSP), and air navigation service provider (ANSP). As a result, aircraft taxiing will have real-time location of GSE on moving maps to help avoid collisions during low-visibility conditions. With advanced technology and decision support systems, trained ANSP and ramp management staff are able to effectively manage high traffic

volumes, including super-density operations, on the airport surface. Just-in-time schedule adjustments in response to demand are identified and made easier to implement.

3.2.2 Airside Resource Systems for Facility Management and Emergency Response

As aircraft operations grow with NextGen, today's practices of information sharing at airports will need to evolve to support this increased operational demand. With the aid of net-centric infrastructure and services, airport resource management systems will assist airport operators in the synthesis of real-time information and the proactive management of resources in anticipation of near-term events, typically in an hourly or daily time frame.

Airside functions included in resource management include airfield inspections and maintenance, safety procedures, emergency response services, security inspections, winter operational activities, and gate and ramp management. This includes many of the activities that are required under 14 CFR Part 139 certification for airports with scheduled air carrier service. Resource management systems help airport operators to keep facilities open and available in all conditions. Sensors on the airfield collect data such as weather and pavement conditions, and integrated systems are able to detect anomalies like debris (e.g., foreign object debris). With integrated four-dimensional weather information, resources will be aligned with operational demand in order to reduce delays. Resource management will also assist airports with actively monitoring environmental conditions such as noise, air quality, water quality, and wildlife hazards. Resource management systems feed into the airport operations center where the information is used to help manage airside functions.

Response to airport emergencies and disasters are executed following local standards that are in alignment with national standards and protocols. This alignment enables a seamless integration of regional and national response resources when needed. Additionally, integrated and standardized national and local shared situation awareness capabilities are used to enhance the coordination and collaboration among stakeholders involved in airport emergency response. Continuous monitoring and management of routine and emergency airport operations is supported by airport resource management systems. The emergency response mechanisms at airports are closely tied to security functions (see Chapter 6) and are heavily leveraged by Network-Enable Operations (NEO), which is able to instantly recognize an issue at the airport (e.g., fire, incursion, accident, other incidents) and dispatch the appropriate response. In addition, three-dimensional displays (virtual reality and live) provide a clear picture of the incident, enabling the airport operations center to accurately and efficiently manage and support the response. Communications links are quickly established and information automatically routed to the appropriate user groups. Adjacent jurisdictions and relevant regional and/or national entities are able to directly access NEO and provide the most efficient support possible. Effective operational training is conducted under the National Incident Management System.

3.2.3 Winter Weather Operations

At airports with significant winter operations, airside resource management systems will provide guidance for scheduling, prioritizing, and actively managing de-icing/anti-icing operations for

both aircraft and airport movement surfaces during winter weather operations. During winter weather, predictions of surface conditions of the runways and taxiways are provided by the resource management systems to guide treatment crews on optimal strategies to keep runways and taxiways clear and serviceable. Using advanced technology, airport ground equipment and landing aircraft measure runway friction. The runway friction measurements are automatically disseminated in an accurate and timely fashion using NEO, to aid landing aircraft in calculating landing distance during high-density operations. The International Civil Aviation Organization SnowTam program is used as an effective template for reporting winter conditions.

Use of predictive weather capabilities and icing sensors and monitoring icing holdover times (as defined by the flight operator) are included in the four-dimensional trajectory (4DT) and flight object. Improved deicing/anti-icing technologies are used to expedite the process and reduce delay. These systems help reduce the use of deicing and anti-icing fluids. Water quality is improved via best management practices for storm water management (to reduce hydrocarbons, metals, and other monitored pollutants) and collection methods for spent deicing/anti-icing fluids. Sensors automatically detect pollution thresholds in local waterways in order for the airport operations center to take necessary actions, including diversion of used deicing/anti-icing fluids for storage for later treatment. Aircraft and surface deicing product usage are automatically monitored for reporting, mitigation, and compliance with environmental goals.

Deicing is a significant operational, environmental, and safety issue that will continue to provide challenges in NextGen. The use of deicing and anti-icing with freeze-depressant point fluids involves subjective contamination inspections of critical aircraft surfaces with inadequate or nonexistent tools to monitor conditions that affect estimated fluid holdover times. Current procedures are inefficient, provide a less-than-optimum margin of safety for winter operations, and are environmentally unfriendly. NextGen will need improved methods for both deicing and anti-icing.

Research is needed on alternative methods to both deice and anti-ice aircraft. Research is underway in the use of infrared energy to deice aircraft, but the effects of infrared energy on aircraft composite surfaces need further study. Also, depending on specific facility requirements, infrared solutions are not always cost effective. A more environmentally friendly Type 1 deicing fluid is also desirable.

Anti-icing must evolve beyond the current use of fluid protection with estimated holdover times. The issue of weight has discouraged aircraft manufacturers from incorporating ground anti-icing systems on their airframes; however, lightweight and energy-efficient deice/anti-ice systems are needed for the next generation of aircraft. Short of that capability being developed, NextGen will continue to rely on fluid deicing/anti-icing technology that is used today.

3.3 TRANSFORMED LANDSIDE AND PASSENGER TERMINAL OPERATIONS

More people and cargo will be moving through landside areas at airports, including passenger terminal buildings and ground access to get to and from an airport. Accordingly, efficient passenger flow management and efficient connections to intermodal ground transportation modes can be enhanced with effective airport resource management systems.

3.3.1 Landside Resource and Passenger Flow Management

As air travel demand grows with NextGen, today's practices of information sharing at airports will need to evolve to support this increased operational demand. With the aid of net-centric infrastructure and services, airport resource management systems will assist airport operators in the synthesis of real-time information and the proactive management of resources in anticipation of near-term events, typically in an hourly or daily time frame. Landside functions will also benefit, including terminal passenger flows, security screening status, parking, and airport curb status.

Efficient passenger flows in airport terminals are important so that congestion, queues, and baggage do not impede passenger movements. NextGen will define a minimum level of service to support this mission. Passenger (and other airport customer) flows are impacted by signage (e.g., Flight Informational Display Systems/Common Use Terminal Equipment), public transportation, regional transportation, parking, conveyance systems, terminal space layouts (including gates, concessions, and restrooms), airline business models, and marketing. In addition, changes to security protocols can create bottlenecks, thus impacting the ability of a passenger terminal to meet the needs and goals of NextGen.

In order to meet the NextGen goals for smooth passenger flow management, coordinated information is broadcast to users, including current status and forecast for security wait, Customs and Border Protection processing, and flight status. Although these systems exist today, they are not sufficiently synchronized to facilitate passenger flows. NextGen provides open information standards for a centralized, wireless-enabled system to disseminate passenger flow information at key airports to include ground transportation connectivity, weather, delays, parking availability, and check-in times within a single network.

3.3.2 Passenger Processing and Security

In NextGen, advances in common-use systems continue with existing trends toward automated issuance of boarding passes (whether paper or paperless) and faster processing of passengers. As discussed in Chapter 6, the SSP is responsible for regulating, managing, and/or implementing new and transformational technologies and procedures to ensure system security using integrated risk management. Typically, a departing passenger is able to arrive at the airport curb, get his or her boarding pass and check baggage (as needed), clear security screening, and be at the gate within 30 minutes.

3.3.3 Off-Airport Passenger and Baggage Processing Enabled through Integrated Trip Tracking

An enterprise service provides for integrated trip tracking of baggage and passengers that adheres to industry-defined standards of service, reliability, maintainability, and universal access. The system supports tracking of passenger and baggage information (e.g., radio frequency identification [RFID]), synchronization, itinerary/handling information, remote check-in, and security assurance. The system does not transfer passenger and baggage between venues, but supports the continuous tracking and availability of the plan, intent, and current locations of

passengers and their baggage. Through an open information standard, transfer of passenger baggage is enabled (e.g., a passenger renting a car from a rental car company picks up the luggage at the rental car rather than at baggage claim).

The Remote Tower Sensor System (RTSS) facility provides added value to conducting full-spectrum screening of both passengers and bags, as described in Chapter 6. Then, cleared passengers and bags are transferred in secure ground transport to the sterile portions of the airport terminal. Alternatively, self-tagged bags with RFID can be transported from off-airport terminals (that do not conduct security screening) to the airport by the passenger and then accepted by the air carrier for transport prior to the passenger security screening. Depending on their specific needs, airports are able to adapt off-airport terminals of varying capabilities into their operations.

The passenger and bag tracking system decentralizes passenger processing and allows bag processing to be conducted in an out-of-the-way area of the airport, if appropriate. This increases capacity, reduces check-in time, reduces personnel requirements, and enables tracking. Both bags and passengers are known information, allowing 4DT aircraft departures in a more reliable manner. Passengers and bags are treated as information monitored by the passenger remotely (e.g., via mobile phone or handheld device). Demands on aircraft operator check-in personnel are reduced, as is space in the terminal for check-in. Arrivals baggage claim is not used by passengers but instead is an industrial sorting center at a remote part of the airport (similar to cargo operations). Information management and data exchange is integrated into NEO.

3.3.4 Intermodal Ground Access

Intermodal ground access is needed so that air services will connect with intermodal transportation, as appropriate, within each regional transportation system in order to provide efficient ground access. Passengers have a variety of options with intermodal ground access transportation, including public rail and bus transit, taxicabs, shuttle services, and even private automobiles. With high-quality, readily available information on intermodal ground access that is integrated into their itinerary, passengers will be able to make informed decisions about travel to and from the airport. The development of intermodal transportation systems that connect with airport ground access is also identified as an important component to support NextGen. Intermodal transportation links are an important component in making regional airport systems viable.

Inclusion of intermodal links in this Concept of Operations (ConOps) is not meant for funding or program implementation by NextGen, but rather to highlight the need for airports to work with their communities to integrate airport and landside access/transportation planning. Because most passengers and cargo get to the airport via the roadway system, increasing activity at an airport puts added pressure on the regional road network. Moreover, intermodal transportation improvements are needed to support off-airport passenger and baggage processing, as described in Section 3.4.3.

3.4 TRANSFORMED AIRPORT DEVELOPMENT

Long-term planning and infrastructure development will enable the U.S. airport system to accommodate increased operational demand while maintaining a high level of service.

3.4.1 Airport Preservation

A diverse network of airports must be preserved throughout the nation in the best interest of an efficient national air transportation system. This includes all types of airports, inclusive of major air carrier airports and smaller, supporting airfields that act as relievers and regional airfields. All are vital to the future success of NextGen; however, many airports are at risk from encroachment or closure, and preservation of these resources is vital to the success of NextGen.

Today, airports provide a community with a fast and efficient gateway to the domestic and international air transportation system. Many companies consider proximity to an airport a key reason for locating their facilities, including proximity to smaller airports that have sufficient infrastructure to support business jet operations. This will become even more apparent as air taxi operators using very light jet (VLJ) business models come into operation during the next decade.

Supporting airports are also a vital resource during emergencies. Emergency response activities are often staged out of smaller airports, including responses to natural disasters such as hurricanes and wildfires. Without efficient airport access, emergency response services would be more constrained.

The sustainability of existing airports is critical to the future growth of communities and to the nation's air transportation system. Within NextGen, increased use of supporting airports is envisioned as a critical component to increasing total system capacity and thereby accommodating increasing demand. With the deployment of new precision approaches to most airfields, enabled by satellite navigation technologies and Required Navigational Performance (RNP), access to supporting airports becomes safer and more reliable. Increasingly, aircraft operators make maximum use of the existing infrastructure at supporting airports in order to avoid congestion and higher costs at major airports. A diverse network of airports is also needed to support new and emerging aircraft, including unmanned aircraft systems (UAS), Vertical and Short Takeoff and Landing (V/STOL), supersonic aircraft, and commercial space vehicles, as well as to support the ever-changing needs of the military. Where appropriate, increasing the utilization of existing and new joint-use facilities provides for improved civil access to the National Airspace System (NAS).

The primary threats to airport preservation are land-use encroachment of incompatible uses, conversion to non-airport uses, lack of sustainable capital and operating finance mechanisms, and lack of community support. Land-use encroachment and development has long been a concern to airport operators and users. Land-use decisions are local and state concerns that reflect the political nexus of many interests: residential communities, developers, local governments, and airport users. Lack of support from communities that do not understand the importance of their airport is also a key factor. Accordingly, advocacy and sponsorship of the airport by local businesses, users, and the community is important for long-term preservation.

At the state level, several successful programs exist for airport protection, including those of the State of California (Airport Land Use Commission), the Washington State Department of Transportation, and the Maryland Aviation Administration. In addition to noise exposure and airport protection surfaces, some state programs evaluate areas adjacent to airports that can be affected by undesirable light, glare, fumes, vibrations, smell, and low-flying aircraft activity. These effects are most pronounced under the airport traffic pattern, which can extend several miles from the runway. According to some state programs, negative effects generated by airport operations in these areas can present health and safety problems and degrade quality of life for residents.

Within NextGen, a new airport preservation program is needed to enhance the sustainability of at-risk airports. In coordination with the National Plan of Integrated Airport Systems, at-risk airports would be identified via input from users, airports, and others with interests in airport preservation. States, airports, and metropolitan planning organizations (MPO) would be partners in the implementation and success of the program. The FAA would participate in identifying and protecting critical airport infrastructure without changing airport operator responsibilities and state and local determination of land use. In addition to airport advocacy and fostering community support for airports, the program would seek to align federal airport programs toward the goal of long-term airport preservation.

Long-term maps (i.e., 20-year maps that coincide with comprehensive planning standards) of the airport protection surfaces, existing and future noise levels, and safety zones would be prepared for airports that participate in the program. Airport programs under 14 Code of Federal Regulations (CFR) Part 150 and Environmental Management Systems (EMS) would be aligned with the Airport Preservation Program in the interests of protecting land-use compatibility, preventing encroachment, and enhancing environmental sustainability. A robust obstruction evaluation process and comprehensive maps of airport protection surfaces (i.e., 14 CFR Part 77 and Terminal Instrument Procedures [TERPS], as applicable to NextGen) would help prevent new structures from exceeding height restrictions, and thus constrain instrument approach access to airports during inclement weather. Depending on the state enabling legislation for land-use decisions, the long-term mapping could be integrated into airport overlay zoning in order to curtail new development with the potential to affect airport preservation or future expansion plans.

Through intergovernmental agreements, information on proposed land-use development actions within the long-term mapping (e.g., issuance of building permits, zoning amendments, and comprehensive plan updates) would be shared with airports, local governments, MPOs, state aviation agencies, and the FAA. This information sharing could assist with problem identification and aid in building consensus on development actions. For example, participating organizations could have the opportunity to review and comment on the development actions for suitability with airport plans, federal grant assurances, community interests, and the long-term sustainability of the NAS. Potential recommendations on the proposed development actions could include consent/approval, disapproval, or a recommendation to amend the plan to include easements, noise mitigation, and disclosure requirements. The jurisdiction seeking to approve the development plans would respond to the comments and provide their reasons for acceptance, rejection, or amendment. Depending on the governing laws of the state and local jurisdictions, varying legal remedies could then be available.

At a regional level, the identification of former military bases (e.g., as part of the Base Realignment and Closure process) that have potential civilian aviation uses could continue to be an important component in enabling aviation growth. In heavily developed regions, these former military bases may be the only realistic option for expanding regional airport access and capacity. Through NextGen, the conversion of suitable former military bases to civil aviation use is facilitated through integrated, long-term regional planning that identifies future applicable aviation uses for the facilities.

The obstruction evaluation process is more effective so that the airspace around airports is protected from encroachments that diminish aviation safety and reduce airport access and efficiency during inclement weather. As discussed in Section 3.5.6.2, a new geographic information system (GIS)-based enterprise service will permit integrated obstruction analyses inclusive of the current 14 CFR Part 77 and TERPS obstruction criteria as well as the protections needed for air carrier one engine inoperative takeoff performance criteria, dynamic RNP, and other advanced flight procedures. By making the obstruction analysis process more robust, builders and the FAA are able to evaluate proposals and alternatives thoroughly and efficiently. As a result, airports and aircraft operators are protected from obstructions that impact approaches and capacity, thus aiding in the preservation of airports as a component of NextGen.

3.4.2 Catalysts for Airport Development Actions

While long-term development planning is an important tool for identifying potential infrastructure development projects, specific catalysts are needed to move projects from the planning stage to implementation. Historically, new gates and terminal layouts were built to accommodate widebody aircraft, regional jets, and hubbing operations. Airfield construction, including terminals, new runways, and runway extensions has been done in response to specific localized needs.

More recently, new security procedures such as the need for in-line baggage screening have driven further changes. In an era when airport security has become a national priority, airports have been able to accommodate new and evolving infrastructure needs in order to guarantee aviation security. In coordination with SSPs, airports have been able to accommodate screening passengers and baggage with relative efficiency despite significant challenges associated with implementation. Rather than being driven by long-term planning, these efforts were undertaken in response to specific events. This illustrates the need for increased flexibility in airport planning, development, and operations.

At airports with substantial scheduled airline service, air carriers typically consent to pay for a substantial part of infrastructure development through lease agreements and user fees. Accordingly, development activities typically do not move forward until there is general consensus from the users on the need for the project. While new technologies are important drivers of airport transformation, the financial and political support from users is critical to project implementation, due in large part to the significant capital and time investments required for infrastructure projects. A forecast of long-term demand alone is not sufficient, given the cyclical nature of the aviation industry. There must be a definite, reasonably foreseeable need for the project. As a result, the development history of any particular airport is unique and is a

reflection of that facility's layout, aircraft operation types and activity levels, user demographics, and governing political systems.

Potential solutions to NextGen's critical issues need to be evaluated using metrics relating to aircraft quantity, size, performance, capacity, landside access, and level of service. Interpreting the various metrics with an understanding of how changes might affect the entire network of airports is key. For example, solutions implemented at a number of major airports may cause significant and negative impacts at supporting airports, or vice versa. To achieve balance, NextGen must recognize the diversity of airports and work to integrate the national planning process with site-specific facility planning, financial planning, environmental sustainability, and regional system planning. This approach, combined with benchmarking, market analysis, effective policy, operational procedures, and technology will help identify the appropriate airport infrastructure necessary to develop an integrated airport system and thus meet the goals and objectives of NextGen.

3.4.3 Efficient, Flexible, and Responsive Airport Planning Processes

Solutions to critical airport issues need to be balanced against other aviation metrics such as aircraft operational and passenger capacity, safety, level-of-service standards, landside access, and environmental goals. For each of these, the NAS will need to have a clear image of different airport types and the domino effect that could ensue as a result in major aviation policy changes. For example, solutions that are implemented at a number of large airports may cause significant and negative impact on smaller airports, or vice versa. To achieve the proper balance, the future airport system will require the ability to integrate multiple planning processes and analyses to determine the appropriate airport infrastructure necessary to develop the future integrated airport system plan.

In NextGen, processes that encompass traditional master, financial, and environmental planning activities are integrated into a single, comprehensive architecture that enables more efficient, flexible, and responsive planning. NextGen goals are integrated into the planning process, as are ANSP coordination activities that are needed to ensure the successful implementation of airport improvements (e.g., so that airport planning actions take into account airspace constraints). Regional considerations such as the specific roles of airports within a system, availability and need for intermodal transportation links, and the comprehensive plans (including land use) of local jurisdictions are key factors in successful airport planning efforts. By integrating these diverse activities into a complete process that is efficient, predictable, and transparent, oversights are reduced and capabilities are enhanced. Effective public involvement is also critical to ensuring that the community is aware of and can support airport infrastructure development.

FAA-supported finance mechanisms are available to support integrated planning processes as well as coordination actions for NextGen and ANSP. For major airports, planning is envisioned to occur on an ongoing, annual basis in connection with capital improvement programs and performance management activities in order to identify long-term gaps and emerging trends and respond appropriately. A continuous, integrated planning process supports current environmental streamlining activities by speeding the identification and dissemination of airport data as well as improving data comprehensiveness and quality. The continuous planning process also supports the EMS process discussed in Chapter 7.

The impact of aviation on the surrounding environment is a critical study element in the development of airport infrastructure. As air traffic grows, airports need to operate in a more environmentally sustainable and energy-efficient manner to prevent environmental degradation. Sustainability and environmental management measures will be incorporated into proposed facilities, programs, and procedures.

Environmental regulations for airports fall under the jurisdiction of many agencies representing federal, state, and local (city, county, municipality) governments. At many airports, community and stakeholder groups are also involved in environmental management. Although the process is essential to the preservation of an environmentally sustainable airport system, the cost (in terms of both time and money) associated with the environmental approval process can (today) constrain the expeditious implementation of airport capacity initiatives such as additional apron and gate expansion, landside access projects, and airfield improvements. With a planning process that integrates airport, financial, environmental, and regional planning activities, airports will be able to more quickly satisfy emerging infrastructure needs.

Post-implementation evaluation of actions will be an essential component of the planning process, so the actual benefits of new infrastructure can be quantified and compared to the planned estimates. This supports a lesson-learned function in planning activities in order to identify successful project strategies and valuable lessons learned. EMS will be used to monitor and review and to provide information to adapt and improve.

3.4.4 Regional System Planning

Increased support at a national planning level will be needed to (1) promote intermodal and ground transportation initiatives directly related to using alternate airports, (2) manage demand among a system of airports, and (3) protect airports from non-compatible development while also recognizing the land-use needs of communities in the vicinity of airports. In terms of long-term sustainability, airports and local governments must work together to improve compatibility and to protect airport and community resources, including consideration of off-airport environmental and community planning issues. Comprehensive, integrated regional system plans are critical to achieving these objectives.

Planning for airport systems, intermodal transportation, and land-use are integral components of comprehensive regional system plans:

- Airport system planning includes activities to determine the role of each airport within a system, estimate aviation demand, determine infrastructure needs, and provide for environmental management.
- Intermodal transportation planning includes activities for highway, high-speed bus, and rail (including light, heavy, high-speed, and freight) connections between airports, RTSS facilities, central business districts, regional transportation arteries, and residential areas.
- Land-use planning includes activities to integrate airport compatibility standards for aircraft noise and obstructions into the comprehensive plans implemented by local

jurisdictions, while also considering the development, revenue, and demographic needs of the communities.

These components are interdependent; for example, the lack of appropriate intermodal connections can constrain use of an airport, regardless of available terminal and airside facilities. Without sufficient ground access in the form of intermodal infrastructure, super-density airports may be able to accommodate a higher number of aircraft operations, but will not be able to deliver the passengers and cargo on the ground required to maintain an efficient transportation hub. Similarly, an airport that is used as an alternate facility will not be successful if efficient intermodal connections are not available to transport passengers and cargo to their ultimate destinations.

In addition, local land-use decisions can constrain future airport growth:

- Decisions to permit development of non-compatible land uses can increase the number of people living within existing and future noise impact areas; this will ultimately increase the cost of airport expansion or curtail it altogether.
- Development of tall towers and structures can create new obstacles that impact instrument approach procedures (IAP), airport protection surfaces, and aircraft performance/flight profiles; this constrains airport access.
- Other development can affect runway protection zones and other safety zones.

Through regional system plans, airport operators can take a more active role in local land-use planning by being involved in the development, review, and implementation of comprehensive plans that are used to manage local land use. Proactive use of multiple land-use management tools, including disclosure requirements, conventional and overlay zoning, land banking, and development rights will also be important. Efforts to prevent new obstructions to air navigation (e.g., radio towers) from constraining aircraft performance and instrument arrival/departure procedures at an airport will also be part of the regional system plan.

In order to manage interdependencies, multiple components will be integrated into the regional system planning process. Through consideration of the needs, constraints, and goals of aircraft operators, communities, and other stakeholders, the regional system plan will serve to integrate decision making for airports, intermodal transportation, and land use. The regional system plan would provide guidance on the specific activities undertaken by local jurisdictions and airport operators for ground transportation and land use development. Potential environmental impacts and benefits will also be assessed, using appropriate metrics and impact criteria for noise, air quality, water quality, and other effects. Primarily, regional system planning would be most critical for major metropolitan regions with multiple airports and a diverse transportation network.

While regional system planning is not a new concept, it will become vital to the success of NextGen when addressing the challenge of increased aircraft operations, passenger, and cargo demand. Specifically, airport planning processes will need to incorporate regional components, including regional policy decisions. Airports will provide local and regional transportation planning agencies (e.g., MPOs) with proposed development plans (including master plans) for

review and comment. In addition, airports will collaborate with surface transportation agencies in their planning efforts so that airport ground access needs can be considered in the context of the overall regional transportation planning and programming process. Similarly, airport operators should be engaged in reviewing proposed surface transportation plans and programs to ensure that the transportation access needs of the airport are properly taken into account.

Federal, state, and local roles in regional coordination and decision making will need to be defined in support of NextGen goals. Appropriate policy guidance and finance mechanisms will be identified and made available to support regional system planning and intermodal infrastructure development. For example, regional system planning could be transformed if federal funding for supporting major airports is tied into the role of the metropolitan region within the NAS, rather than using the number of enplaned passengers as a primary measure.

An important element in regional planning is the recognition of the roles, responsibilities, and legal authority of the federal, state, and local jurisdictions that have interests in regional planning. Ultimately, the decisions to move forward on most airport and regional transportation projects are made by local governments with guidance and financial support coming from the state and federal levels. For example, the federal government does not allocate demand to specific airports. Rather, market-based interactions in consideration of airport facilities, ground access, socioeconomics, and so forth determine how many and what types of flights operate at a specific airport (within a system of airports). For the purposes of NextGen, a better understanding of how market and non-market mechanisms affect the choices made by aircraft operators to serve specific airports is needed so that regional needs can be better forecasted and incorporated into decision making.

3.4.5 Flexible Terminal Design

Today, passenger terminals are experiencing an ongoing shift from traditional modes of operation. The airline industry has shifted to new operational efficiencies based on low cost and high volume. This shift is largely a result of carriers that have successfully driven changes in traditional operating models, including an increased reliance on automation of passenger check-in that results in reduced queue times at ticket counters.

Design guidelines for NextGen Airport Passenger Terminal Buildings will be needed to (1) facilitate the flexible integration of new NextGen technology and procedures (e.g., advanced passenger and baggage processing, remote check-in, and security), and (2) assist in the development of new terminal layouts and signage that promote smooth passenger flows during busy periods. With flexible terminal designs, changes in processing technologies and security screening requirements can be accommodated in a terminal envelope that enables rapid reconfiguration of the building to meet ongoing needs. Available infrastructure would support common-use facilities such as gates, ticket counters, kiosks, and information systems. Note that the common-use infrastructure is not intended as a federal mandate; each airport and its users will determine gate allocation based upon its specific needs and factors related to efficiency, cost, and availability.

New terminal designs will increasingly incorporate provisions to support energy and resource conservation, including green design and technologies.

3.4.6 Optimized Airfield Design

Airfield design planning and engineering standards need to be optimized to take full advantage of NextGen-driven ATM improvements. Standards are needed to guide the design of new infrastructure, deployment of sensors and navigational aid (NAVAID) equipment, and support operations at airports by new types of aircraft.

3.4.6.1 Closely Spaced Parallel Runway Operations

Procedures that permit independent aircraft operations to/from closely spaced parallel runways (i.e., with smaller separation standards than those in use today) maximize the capacity of existing infrastructure. In terms of airfield design, reducing separation between parallel runways needed for independent aircraft operations reduces the land needed for runway development. One of the major limitations to new runway development is the lack of available land to develop new runways at high-traffic airports, especially in dense metropolitan areas. Specific parallel runway separation standards are a function of ANSP procedures; the development and implementation of new standards will have a substantial effect on airfield design and capacity.

3.4.6.2 Airport Geographic Information Services

The airport operator has an important role in providing accurate and up-to-date GIS data to other elements of NextGen. Today, the lack of ready access to accurate and up-to-date airport surface GIS data is a significant issue with existing automation systems.

System-wide airport planning for the NAS is difficult today because of the diverse standards and formats of information. Because each airport has responsibility for its own planning and development, the information quality, structure, and format is defined by each airport according to individual needs and budgets. The non-interoperability of many of the formats, and the difficulty of conversion between formats, also inhibit simple exchange of airport planning information.

In order to meet the goals of NextGen, high-quality airport data and information need to be available in a centrally managed, comprehensive repository. For example, the flight hazard/obstacle review process can be automated through distributed GIS with information on Part 77/TERPS surfaces and obstacles. This data can be used to support safety assessments and hazard mitigation tracking. Airport layout plan documents would be available in a central repository available through a managed access process (e.g., an airport map database). Other components, such as noise and emissions data, land use, historic aircraft trajectory data, and completed studies would also be available in the central repository. As appropriate, these systems would be developed in GIS-based formats.

3.4.6.3 Obstacle Measurement and Data Distribution

Landing and takeoff minimums (i.e., required ceiling and visibility weather conditions) are lower at airports served by IAPs with the development of a robust and accurate national obstacle database. Today, there are many airports with higher-than-standard takeoff or landing minimums

because of obstructions. In NextGen, mature airborne and satellite-based obstacle identification and measurement techniques supplement present-day ground survey practices. Accuracy tolerances and required clearance criteria currently added to obstacle locations and heights are reduced or eliminated, thereby allowing airspace designers to develop IAPs with the lower minimums. Obstacle data are readily available through a Web-enabled distribution system using GIS technologies. This achieves substantial increases in capacity because it increases access to the airport during low ceiling and visibility conditions.

3.4.6.4 Airport Protection Surfaces

Airport protection surfaces are zones around airports that define the maximum height of obstacles in order to avoid interference with the safe operation of aircraft in the overhead airspace. Today, airport protection surfaces are defined in 14 CFR Part 77 and FAA Order 8260.3, United States Standard for Terminal Instrument Procedures (TERPS). In addition, 14 CFR Part 25 describes the engine out-climb gradients required for operation of air carrier aircraft. The climb gradients are a factor in the determination of takeoff weight. The takeoff weight of a planned flight can be reduced to ensure that climb gradients are clear of obstacles. Accordingly, obstacles can constrain aircraft payload.

Aircraft performance characteristics that increase present-day levels of safety, combined with advanced instrument procedure design criteria, allow for reductions in obstruction clearances and associated protection areas currently required for both ground and satellite-based aircraft flight procedures. This allows arriving aircraft to use lower ceiling and visibility minimums when using IAPs during inclement weather, thereby increasing access to the runway and increasing overall capacity because operations are not constrained due to inclement weather. Lower ceiling and visibility minimums also permit more aircraft to depart airports during adverse weather periods.

Consideration needs to be given to alleviating recent changes to precision obstacle-free zones and final approach surfaces that have had dramatic impacts to airports with displaced landing thresholds.

3.4.6.5 Sensors

NextGen requires the deployment of new sensors on the airport. Sensors may be needed in the runway environment for the active detection and dissipation measurement of wake vortices, which will enable reduced aircraft separation during conditions when wake turbulence is not a hazard. Advanced weather sensors are also deployed to airports, including sensors that provide a detailed picture of the atmosphere along the airport approach and departure paths in order to detect the varying conditions that may affect flight operations and wake vortices. Placement criteria, non-interference zones, maintenance requirements, and other necessary considerations for the sensors are incorporated into airport design standards.

3.4.6.6 NAVAIDs

The transition to satellite-based IAPs frees up airport surface movement areas previously constrained because of ground-based navigation systems (e.g., instrument landing system [ILS]-critical areas). NextGen requires less ground-based radio navigation infrastructure to support

IAPs than is used today with ILS and other systems. Therefore, ILS-critical areas and other zones designed to protect instrumentation from interference are less of a constraint. This facilitates the efficient movement of aircraft on the airfield.

3.4.6.7 Other Design Factors

In NextGen, airports have runway safety areas that meet applicable FAA airport design standards in order to support potential aircraft overruns. Where sufficient land is not available or improved runway safety areas are not practical, alternative mechanisms to prevent overruns are implemented (e.g., Engineered Material Arresting System).

Unique infrastructure needs for UASs, V/STOL, space planes, and other new flight vehicles are incorporated into airport design standards. A new collision risk model may permit use of larger aircraft in existing object-free zones.

While efforts to increase runway capacity are vital to NextGen, the ground and gate capacity of the airfield is also critical. The ground interactions between GSE, people conveyance systems, and aircraft on the apron and taxiways, as well as aircraft crossing runways, is a significant constraint to capacity. For example, super-density operations may require end-around taxiway systems and other changes to airfield layout in order to minimize the need for runway crossings by taxiing aircraft. At night, the apron space required for overnight parking of aircraft also increases substantially. The reduction of ground movement delays and congestion due to constrained airport infrastructure is an important component in enabling NextGen, as is providing sufficient gate capacity.

Ultimately, no single strategy will increase the capacity of the NAS and airports. Rather, a thorough analysis of the multiple components in the system and their interactions will provide the optimum combination.

3.4.7 Airport Congestion Management

Congestion management programs at major airports may be used to manage short-term situations where demand exceeds the available capacity of the airport infrastructure. A combination of regulatory and market-based mechanisms could be used to balance the competing needs of aircraft operators seeking airport access, for airports to provide a reasonable level of service, and for the ANSP to accurately predict the impact of local congestion on the NAS and mitigate the ripple effects throughout the NAS.

Congestion management is discussed in this ConOps in an effort to track the ongoing policy discussion regarding airports where infrastructure development and ATM capacity improvements are not likely to be sufficient to meet future demand (e.g., New York LaGuardia). Accordingly, congestion management is a policy issue rather than a specific concept; however, the policy choice made regarding congestion management likely will affect some airports in NextGen. Congestion management also differs from cooperative ATM concepts that seek to meter traffic in and out of congested airports rather than manage airport access.

The congestion management program could incorporate mechanisms to facilitate aircraft operator competition (e.g., gate access for new entrant carriers) and ensure major airport access

for flights from smaller communities. For example, congestion management could affect the viability of service from small communities to airports such as New York LaGuardia and thus convenient access to major economic centers such as New York City. If congestion management increases the cost of airport access, flights from certain small communities to major economic centers may not be economically sustainable. Alternatively, the market-based incentives could shift flights to/from smaller cities to off-peak times, which may not be conducive to convenient travel schedules. Such adverse effects would be mitigated through specific measures within a congestion management program.

In addition to short-term situations, consideration may be given to allowing airports to impose long-term peak-period landing fees that will both help manage congestion at large airports and bring increased revenue to the airport for use in modernization investments and other improvements that will assist in meeting growing passenger and freight activity. Existing federal statutes require revenue neutrality, preventing the airport from increasing user fees if they produce revenues that exceed airport costs. Changes to federal law in this manner will also encourage greater interest by private investors to invest in airports.

Within the congestion management program, the roles and responsibilities of federal, state, and local government decision makers as well as the airport operator will need to be determined. As discussed previously, the disposition of revenue over and above airport needs will need to be determined, including the potential use of this revenue to support the economic sustainability of airport infrastructure.

3.5 CHALLENGES TO NEXTGEN AIRPORTS

The current U.S. airport system is composed of approximately 20,000 airfields,[8] the majority of which are small, privately owned airfields that support a significant general aviation community. Of the 20,000 airfields, about 25 percent are open to the public. The FAA certifies airports that have air carrier service by aircraft with nine or more seats; only 559[9] airports are so certified under 14 CFR Part 139. The diversity of airports is an important consideration. Each airport is a unique operating environment to a far greater extent than the analogous airspace structures. Different airport layouts, constraints, and procedures pose unique challenges to achieving and maintaining efficient operations at peak capacity without sacrificing safety.

Many of the factors that currently drive airport development are primarily market-driven, rather than falling under the control of the airport operator or federal government. Even as airports are responsive to their users, the users are responding to market factors. Airport users include flight operators, the traveling public, and neighboring communities that benefit from and are affected by the airport.

Many factors will drive airport development and operations through 2025 and beyond. These include the following:

[8] U.S. Department of Transportation, Federal Aviation Administration, Administrator's Fact Book (Washington, DC: Annual issues), Internet site http://www.ama500.jccbi.gov/factbook/ as of May 21, 2004.
[9] FAA 14 CFR Part 139 Certification Status Table, Internet Site http://www.faa.gov/airports/airport_safety/part139_cert/ as of September 4, 2009.

- Some major airports that are at or near capacity today may not be able to reasonably expand to support substantial additional capacity. This will drive development of other airports in congested metropolitan regions.

- Supporting airports will expand by promoting higher levels of service to both aircraft operators and passengers, potentially pushing integration into the hub-and-spoke system and stimulating changes in the airline hub business models.

- Congestion and the "hassle factor" will drive some passengers' decisions to travel on scheduled carriers with connections through major airports or seek transportation via regional airports with (scheduled/nonscheduled) nonstop service or other modes of transportation.

- Sufficient intermodal transportation networks must be developed to link airports with population and business centers. People and cargo must be able to get to and from the airport in a predictable and efficient manner.

- Federal, state, and local agencies must evolve to support the effective governance of NextGen airport operations and regional considerations, given the many stakeholders who have vital interests in a successful airport system.

- New aircraft technology will allow long-range flights with medium seating capacity, thus promoting point-to-point service to smaller airports.

Beyond traditional airline operations, new service offerings are expected from operators of V/STOL aircraft, VLJs, and space vehicles of various kinds (e.g., orbital and suborbital space vehicles and point-to-point suborbital space planes). These new services are expected to continue to drive growth in general aviation and nonscheduled air transport operations as an alternative to scheduled air carrier travel.

Newly developed V/STOL aircraft (e.g., tiltrotors) could increase service within large metropolitan areas and thereby promote the development of small-footprint airports designed specifically to serve these operations. Insertion of increased V/STOL operations into major hub airports requires careful design to ensure that conventional aircraft operations are not negatively affected.

VLJs offer the potential to make business jet travel more efficient and cost effective. While the viability and sustainability of the VLJ air taxi business models have yet to be proven, VLJs could substantially increase air service options, especially in communities that currently have limited service. Ultimately, the airport infrastructure needed to accommodate VLJs already exists at most airports, because the aircraft have the capability to operate from shorter runways (i.e., 3,000 to 4,000 feet). With the expansion of satellite-based IAPs to most runway ends and related infrastructure, such as approach/runway light systems and Staffed NextGen Towers and Automated NextGen Towers, all-weather access by VLJs and other aircraft to supporting airports increases. Conversely, VLJ use at major airports and in congested airspace could exacerbate delay levels as a result of increased aircraft operations and the complexities of managing air traffic with dissimilar airspeeds and wake turbulence separation requirements.

Commercial space flight (suborbital, point-to-point, and orbital) offers considerable potential for the next 20 years. Some types of space vehicles could be interoperable with conventional fixed-wing aircraft in order to make the best use of existing infrastructure. This could help the integration of Commercial Space Transportation (CST) operations into congested airspace and airports. Alternatively, CST operations could be conducted at dedicated or dual-use spaceports remote from the busy facilities in metropolitan areas and utilize various kinds of airspace reservations for their transition through the NAS. Although suborbital flights may ultimately bring about a radical change in how people travel between continents and the time required to do so, the impact on airport infrastructure is unknown.

At airports with significant scheduled air carrier service, the physical and functional layout of passenger terminals is likely to evolve in response to changes in passenger processing, aircraft size and geometry, remote data access and sensing, information sharing, and high-occupancy intermodal transportation connections. The trend for passenger check-in at locations outside the airport, such as at home, via mobile phone, and at hotels will continue and expand as remote terminals support off-airport passenger and baggage processing. The infrastructure needed to support security screening should decrease as these processes are integrated and refined to support NextGen.

4 Net-Centric Operations

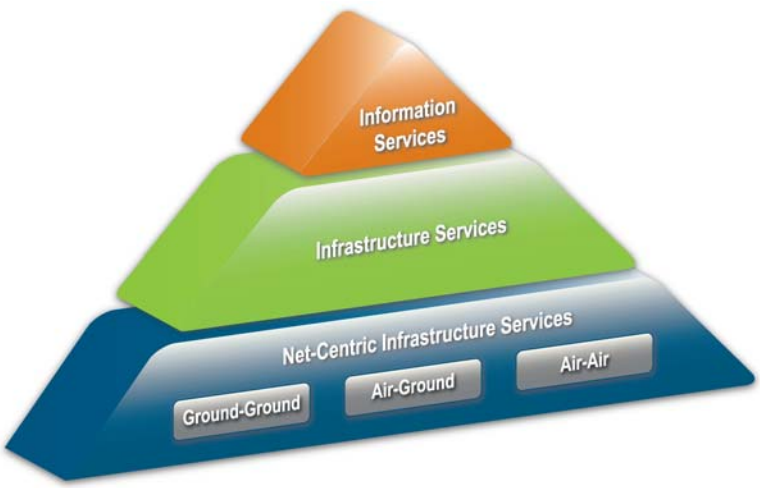
4.1 INTRODUCTION

Net-Centric Operations (NCO) in the Next Generation Air Transportation System (NextGen) encompasses the ability to store, transport, and retrieve air transportation-related information between providers and consumers on a reliable, scalable, flexible, and secure enterprise network through the provision and management of infrastructure resources to sustain normal operations and service level agreements. NCO is the application of network methods and technologies to improve or transform an operation or process, focused on improving the exchange of information throughout the National Airspace System (NAS). As illustrated in Figure 4-1, in the context of NextGen, NCO is the realization of a globally interconnected network environment, including infrastructure, systems, processes, and people that enables an enhanced information sharing approach to aviation transportation.

Figure 4-1 NextGen Information Users

A foundational and transformational component of the NextGen vision is the employment of a net-centric environment for exchanging air transportation-related information. There are two key components of the net-centric environment: Infrastructure Services and Information Services. The infrastructure is the framework for sharing information, while the services direct the information to the authorized users who need it. Examples of relevant information provided by NCO under NextGen include flow/trajectory information, advisories/alerts, surveillance, real-time NAS configuration, aviation security reports, and weather reports/forecasts. Figure 4-2 depicts this relationship between Information Services and Infrastructure Services, and also shows the underlying physical network infrastructure on which both operate:

Figure 4-2 Net-Centric Infrastructure Overview



The NextGen network infrastructure provides an integrated, global network that will incorporate a ground segment, an air-ground segment, and an air-air segment. The ground network is the backbone of the NextGen Net-Centric Environment, carrying inter-facility data in the NextGen network. The ground network will also be an essential support for the air-ground segment, by transporting data to and from the appropriate ground radio equipment. The air-ground network will carry data from ground systems to the cockpit and vice versa. This critical segment of the NextGen network enables the delivery of real-time surveillance, weather data, and relevant security information to the cockpit, and enables the negotiation of trajectories and separation responsibility contracts. The air-air segment will build on existing technologies (such as Automatic Dependent Surveillance-Broadcast (ADS-B)), allowing aircraft to share critical real-time information, including, for example, surveillance and weather data.

Infrastructure Services are focused on providing and managing connectivity. These services handle duties such as access control, the basic transport of data, bandwidth provisioning, network monitoring, and diagnostics. Information Services are built on top of the Infrastructure Services and are focused on providing content in the appropriate ways to the appropriate users. Information Services are tailored to implement the various specific needs within the aviation transportation system. Many types of services are expected in the NextGen environment, including: delivery of weather data from a ground database to the cockpit, sharing security data

between agencies, carrying voice data between facilities, and sharing trajectories between aircraft.

The key to a successful net-centric environment is the establishment of interoperable enterprise networks for the Federal Aviation Administration (FAA), Department of Defense (DoD), Department of Homeland Security, and Department of Commerce. These enterprise networks are a combination of physical infrastructure and Infrastructure Services. Along with information sharing standards, they facilitate the exchange of information necessary to achieve many of the needed operational improvements under the NextGen vision. Note that even once these enterprise networks are established and capable of interoperating, they must be interconnected in order to achieve NextGen capabilities.

Even with the enterprise-level connections and infrastructure in place, without defined processes for people using the capabilities, the NCO Environment is not likely to be effective. Therefore, formalization of an institutionalized sharing process is necessary to provide the policies, processes, measures, and accountability required to ensure that stakeholders integrate access, connectivity, and information distribution into their planning and daily operations.

As shown below, the key NextGen NCO capability, Provide Integrated NextGen Information, is expected to be in the areas of network-enabled information sharing, aircraft data communications links, infrastructure management services, and provision of improved surveillance and air domain awareness. These capabilities require widespread access to secure, accurate, current, and timely information and the capability to share this information securely among the operational entities. The remaining sections in this chapter describe the vision of NextGen NCO.

Provide Integrated NextGen Information: Integrated NextGen information provides authorized aviation stakeholders timely, accurate, and actionable information (e.g., weather, surveillance, aeronautical information, operational and planning information, and position, navigation and timing information) to shorten decision cycles and improve situational awareness using a net-centric environment managed through enterprise services that meets the information exchange requirements of the NextGen stakeholder community.

4.2 TRANSFORMED NET-CENTRIC OPERATIONS

The NextGen NCO provides a robust, globally interconnected network environment in which information is shared in a timely and consistent way among users, applications, and platforms during all phases of aviation transportation efforts. By securely interconnecting distributed users and systems, net-centricity provides a robust, resilient, efficient, and effective information sharing environment, enabling substantially improved situational awareness and shortened decision cycles. The result is that information and data are contained in an integrated, interoperable system with the necessary quality of service (QoS) that enables stakeholders to meet their objectives and achieve operational efficiency. Over time, the Net-Centric Environment responds iteratively to provide infrastructure capabilities of increasing capacity.

The Net-Centric Environment works together with automation to implement “intelligent” system capabilities. For example, wherever possible, NextGen includes the capability to automatically capture any and all relevant data about components of the Air Traffic Control (ATC) environment, including aircraft, baggage, expendable supplies, aircrew, controllers, ground-handling equipment, gates, and passengers, and provide this information to authorized recipients in order to make timely decisions.

Information flows freely from ground to aircraft, from ground to ground, and from aircraft to aircraft as needed. Commercial network protocols and topology are employed with seamless integration between the aircraft, the ground, and the rest of the NextGen information network, making information available to an unprecedented extent. Network connectivity is throughout the air domain and provided from the ground up to all flight altitudes, and includes oceanic and polar regions.

Information sharing is achieved through a robust network among the NextGen stakeholders’ infrastructure. This allows organizations, operational groups, and systems throughout the NAS to collaborate in a seamless information infrastructure, providing for the following:

- Air navigation service, airport, and flight operations
- Shared situational awareness
- Compliance and regulation oversight
- Security, safety, environmental, and performance management services

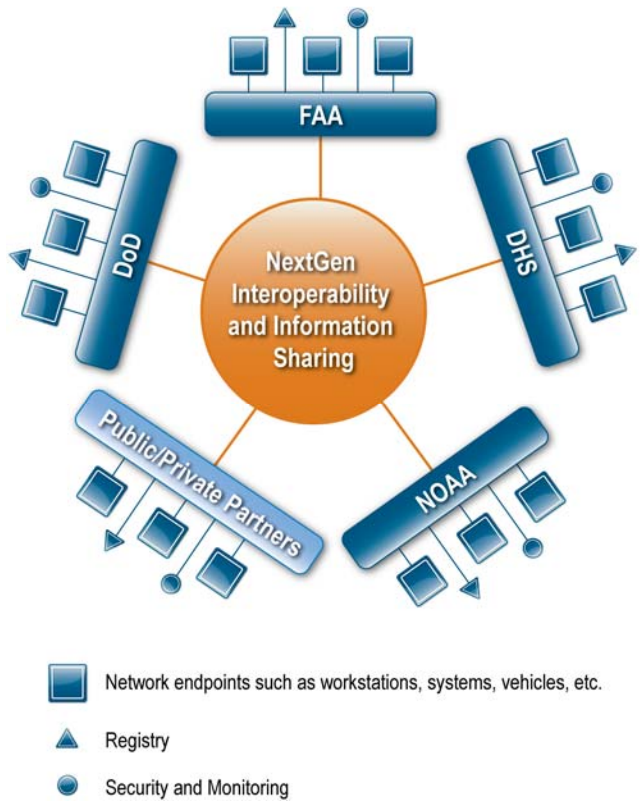
Integration of these operations and services requires an adherence to open standards that maximizes their interoperability across domains. It requires the Net-Centric Environment to provide services that enable secure discovery of and collaborative use of this information for the purpose of effective and efficient operation of the NextGen air transportation system.

4.2.1 NextGen Enterprise Network

As illustrated in Figure 4-3, the NextGen Enterprise Network is composed of the stakeholders’ enterprise networks, joined together and interoperating by protocol conformance and connective infrastructure. This is a “logical” view of the system. Note that each stakeholder enterprise can encompass systems and endpoints of all various types in the aviation community: ground-based computers and workstations, airborne cockpit systems, and so on. The NextGen Enterprise Network provides the following features:

- **Uniform Connectivity Protocols.** Communications transport provides sufficient and dynamic addressing with secure and assured end-to-end connectivity for all nodes in the NextGen air transportation enterprise.

Figure 4-3 NextGen Enterprise Network



- **Data Availability.** Data registries and discovery mechanisms between entities (government, commercial, private, and international organizations) allow for data sharing in a push/pull and publish/subscribe environment between authorized communities of interest (COI).

- **Content Understanding.** Metadata tagging and federated search allow the contents of data to be understood.

- **No Single Point of Failure.** A distributed information environment ensures information reliability, quality, and no single point of failure.

- **Information Assurance.** Secure exchange of information includes access controls, trust relationships, and associated policies and mechanisms to provide appropriate access to information by authorized users. Maintenance of information assurance across security levels and domains is a critical feature of the NextGen Enterprise.

- **Quality of Service.** Data and information are provided at well-known, monitored levels of quality (e.g., data rates, bandwidth, latency). The performance characteristics of NextGen services are digitally captured and maintained in service descriptions and Service Level Agreements (SLA).

4.2.2 Network Management & Security

Infrastructure Services include the network management functional areas of fault, configuration, accounting, performance (including QoS), and security (fault-management, configuration, accounting, performance, and security) management as well as higher level functions such as services management. The emphasis is on an integrated and holistic approach to enterprise network management.

To facilitate information sharing, NextGen must include a cyber security approach that safeguards the information within acceptable trusting relationships between the information suppliers and consumers. Agreement on a trust relationship is critical to making the information available to authorized members within the large NextGen stakeholder community—which includes federal government organizations, state and local governments, the aviation and avionics industry, the international aviation organizations and nations, and the flying public. NextGen information sharing is flexible and adaptable to circumstances and stress experienced by the NextGen system over time. Information access rules are continuously updated depending on the circumstances or events at the time.

The success of NextGen information sharing depends on constituent trust that information is properly protected, that it is not misused or mishandled, and that recipients have a valid need for the data. In turn, this trust depends on applying information assurance policies, designs, rules, and information systems hardware and software that can be tested and certified and on the ability and willingness of the participants to effectively implement and manage their security responsibilities.

4.2.3 Air-Ground Networking

Key to enabling an agile, scalable airspace environment and its management is the deployment of a fully capable aircraft data communications link. This data communications transformation enables aircraft to collaborate with the Enterprise Services. This collaboration includes sharing real-time spatial information, identification, weather, security, and operational status for all aircraft. The operational information sharing includes Positioning, Navigation, and Timing (PNT) and airport status. Furthermore, the data communications link enables the real-time negotiation of four-dimensional trajectory (4DT) collaboration between Air Navigation Service Providers (ANSP) and aircraft. This robust aircraft data communications link also enables a digital voice link to the aircraft. This link enables the flight deck to communicate with all necessary collaborative decision makers and operational entities. Utilizing advanced communications technologies and spectrum allocations—which supersede current limited-capacity data links—there is sufficient bandwidth to support all data types necessary for NextGen (including audio, graphics, and video) with appropriate QoS (including flight-critical data service).

With the transformed role of the flight crew and flight deck and flight management skills in the NextGen, data communications are critical for ensuring that data is available for flight deck automation and that avionics can support flight crew decision making and provide real-time data to the ANSP about operational aspects of flights. Data communications are the primary means of communication between the flight deck and the ANSP for airspaces that require such capability

for clearances and 4DT amendments; for these aircraft, voice communications between the flight deck and ANSP are the exception. Voice communications will continue to be used to communicate with less-equipped aircraft.

Additionally, aircraft communicate via airborne networking capability, based on the level of required performance in airspace they are transiting (equipage policy). The goal is to utilize the optimal combination of assets for communication. It may be aggregated data channels from airborne nodes, space, or ground, but key is the combination, not the primacy, of one approach. Every aircraft is a node on the network, providing information connectivity and relaying information when needed. This network is based on commercial network technologies and provides connectivity for all types of aircraft, from large commercial jetliners to business jets, helicopters, and general aviation. When new information needs or capabilities are identified by the aviation community, the network conveys that information to the relevant end users.

In addition, as indicated above, there is increased sharing of improved common data between the flight deck, operator, and ANSP. In airspace where data communications will be available but not required, information exchange can take place with data communications for participating aircraft to provide an operational advantage. Common data includes ATC clearances, current and forecast weather, hazardous weather warnings, notices to airmen (NOTAM), updated charts, current charting, special aircraft data, and other required data. Data communications also include weather observations made by the aircraft that are automatically provided to ANSPs, weather service providers, and flight operators for inclusion in weather analysis and forecasts. Each of these data communications functions is managed by required communications performance standards. NextGen envisions an open and integrated network that shares information in standard formats, using harmonized services, connecting the information systems used by all users, including ANSPs, agencies, carriers, aircraft, airport operators, service providers, and general users. By securely interconnecting distributed users and systems, net-centricity provides an information-sharing environment that enables substantially improved situational awareness and shortened decision cycles, resulting in significantly more efficient operations and valuable new operational capabilities.

4.3 PROVIDE INTEGRATED NEXTGEN INFORMATION

Mission Support Services addresses access, connectivity, collection, processing, and distribution of information. These are foundational functions of the services that provide information assurance, protocols, and standards applicable for Net-Centric Infrastructure Services.[10] These

[10] ***Access*** is a function of COIs, which are collaborative groups of users (public and private) who must exchange information in pursuit of their shared goals, interests, missions, and business processes. As a result, these COIs require shared and controlled vocabularies and exchange structure and services. COIs are formed based on user needs and common mission objectives. As needs and mission objectives are collaboratively agreed upon, the information and application access requirements to support the needs and objectives can be determined. ***Connectivity*** addresses standardized interfaces, security, and compression algorithms inherent to the addressable Net-Centric Infrastructure. Logical data exchange between COIs is accomplished via internationally standardized and enterprise standardized next-generation communication protocols that are independent of the underlying communications infrastructure. COIs determine the performance requirements of data/information sharing during operations, and the addressable Net-Centric Infrastructure determines the best path to meet the message requirements. ***Processing*** is the collection of information within the Net-Centric Infrastructure that relies on the "smart pull" of information from multiple sources throughout the network. Users subscribe to

functions are crucial to the successful evolution of a Net-Centric Infrastructure. However, without defined processes for people using the capabilities, the Enterprise Service is not likely to be effective. Therefore, formalization of an institutionalized sharing process is necessary to provide the policies, processes, measures, and accountability required to ensure that COIs integrate access, connectivity, and information distribution into their planning and daily operations.

Integral to the NextGen vision is the creation of an environment that facilitates quick and reliable communication and sharing of information, improving situational awareness and shortening decision cycles within the air transportation system. This NextGen capability ensures a robust, scalable, resilient, secure, and globally interconnected net-enabled environment in which information is shared consistently and timely among authorized aviation users, systems, and platforms. This capability reduces the number and type of interfaces and systems required to maximize interoperability and increase collaboration across missions. The seamless flow and integration of information on the ground, in the air, and in between reduces unnecessary redundancy of data and facilitates information sharing targeted to the appropriate decision makers. The improved predictability and access to accurate and timely information allows NextGen users to optimize system resources and communicate status changes or other essential information.

4.3.1 Transformed Network-Enabled Trajectory Management

Net-Centric Operations are vital to the envisioned improvements in NextGen trajectory management. Where many trajectory management processes are manual today, NCO facilitates the transition to efficient, automation-assisted digital processes.

The transition from voice-based air-ground communications to data communications is a key element. For trajectory information (and all other routine exchanges), data is the preferred method of communication between the flight deck and controllers. Voice will be used in cases of emergency such as safety of flight (e.g., a situation where a conflict or midair collision is imminent and voice will preclude an incident), or as part of a backup procedure should data communications experience unforeseen interruptions.

Data communications are central to Trajectory Based Operations, including the use of 4DTs (pushback and taxi inclusive) for planning and execution on the surface, automated trajectory

streams of information that they require to perform their jobs by referencing their geographic location, flight path, time, types of information they need, and other custom parameters designed for their particular needs. The Enterprise Services will then authorize the user to use the system, determine the level of access, and make available certain information feeds specific to that particular user. Information will be collected from multiple sources in a seamless manner, obviating the need of the user to be familiar with where the actual information resides and know that it is authoritative. ***Posting*** is the process of users making raw information available to all of the users in the network by advertising all of their information and posting it so that other users can discover it and make better informed decisions, neither constrained in stovepipes nor available late to need. It is not their responsibility to determine what is important and what is not important to users. ***Pulling*** involves net-centric information flows that permit user-identified streams of data. This customized flow will focus on the communication of the right information versus all information.

analysis and separation assurance, and aircraft separation assurance applications that require flight crew situational awareness of the 4DTs and short-term intent of surrounding aircraft.

Additional details about the role of NCO in trajectory management was discussed previously in Chapter 2.4.

4.3.2 Transformed Network-Enabled Collaborative Capacity Management

The transformations in the delivery of ground, air-ground, and ANSP facility services are fundamental enablers of the flexibility necessary to respond to demand in an affordable and timely manner. Flexible infrastructure supports changing user needs as well as provides cost-effective services that are scaled up and down as needs change. This ensures that the service providers and the information (e.g., flight data, surveillance, weather) are readily available when and where needed.

The sections below discuss NCO-specific aspects of Collaborative Capacity Management. Additional details about Collaborative Capacity Management was discussed previously in Chapter 2.

4.3.2.1 Dynamic ANSP Resource Utilization

A key transformation enabled by the communications network and associated net-centric applications is the ability to provide surveillance, communications, and flight data management, including automation-assisted coordination, to any service provider regardless of its physical location. When coupled with a more flexible air-ground communications network, this transformation supports the optimal daily deployment of NextGen resources and assets. Airspace and air traffic can be assigned without regard to a fixed infrastructure constraint, allowing traffic load sharing across the ANSP workforce on a seasonal, daily, or hourly basis.

The networking capability also provides a robust contingency/business continuity capability. Information systems facilitate monitoring infrastructure health and remote maintenance to maintain service availability and automatically alert the community about the status of NextGen assets. Losses of ANSP personnel workstations due to equipment outages or catastrophic events can be mitigated by reassigning air traffic management and the supporting infrastructure to remaining workstations across the NAS.

Because the flexible ground and air-ground communications networks negate the requirement for proximity of ANSP facilities to the air traffic being managed, facilities are sited and occupied to provide for infrastructure security, service continuity, and best deployment and management of the workforce. This includes co-locating several operational domains (e.g., en route transition, terminal) within a facility as well as staffing virtual towers. The virtual tower and any needed ANSP personnel do not have to be geographically located at the airport, and productivity gains may be achieved by allowing ANSP personnel to service multiple airports according to traffic ebbs and flows.

Some of the obvious drivers for dynamic reconfiguration include the need for efficient traffic flows, the effects of weather, personnel (staffing), staffed virtual towers, and facility or equipment outages, to mention a few. Regardless of the catalyst, the communications,

navigation, and surveillance systems each respond when dynamic reconfiguration procedures are executed.

4.3.2.2 Flexible ATC Communications Boundaries

One of the key transformations is that air-ground voice communications are no longer limited by the assigned frequency-to-airspace sector mapping. This allows greater flexibility for developing and using airspace/traffic assignments in all airspace. Communications paths, including both voice and data, are controlled by an intelligent network. Communications between the ANSP and the flight deck are established when the flight is activated and are maintained continuously and seamlessly. This capability is linked to the flight data management function so that the system automatically manages who has authority to interact with the flight deck based on the type of agreement being negotiated or information being exchanged. Labor-intensive transfers of control and communication are automated. Data and voice communications are automatically transferred in the flight deck as the aircraft moves between ANSPs.

4.3.3 Transformed Network-Enabled Collaborative Flow Contingency Management

Net-Centric Operations bring specific benefits to Flow Contingency Management. The NextGen Enterprise Network provides the stakeholders a highly available, flexible medium for collaboration, serving air carriers, FAA, DoD, or other participant. FAA and DoD can negotiate in near-real-time the allocation of Special Use Airspace and such regions, based on current and projected demand. Air carriers and the FAA can collaboratively tackle issues such as daily weather impacts, route availability, and operational preferences. The capabilities are even more transformative when not only individuals representing these stakeholders can collaborate, but their *automation systems* can increasingly carry out the work of collaboration for them in even more timely and efficient ways.

Additional details about the role of NCO in Collaborative Flow Contingency Management was discussed previously in Chapter 2.

4.3.4 Transformed Network-Enabled Weather

The NextGen Enterprise Network provides the essential “plumbing” (infrastructure) for consistent, timely weather information to pervade the NextGen aviation community. As participants in NextGen weather are particularly diverse and distributed, NCO is particularly important in this domain. NextGen Net-Centric Infrastructure provides the connecting tissue that holds together the “4D Weather Cube,” including weather sensors, databases, forecasting systems, and human participants. It also delivers the Cube’s products to automation systems and stakeholders throughout NextGen. Additional details about the role of NCO in NextGen Weather can be found in Chapter 5.

4.4 AIR DOMAIN AWARENESS

In order to achieve the ideals of improved decision making and efficient operations, stakeholders must have the right information at the right time. This is especially true in the domain of aviation

surveillance. Not only does "shared situational awareness" play a key role in security, it improves operations across the NextGen community. The Net-Centric Infrastructure is vital to conveying and delivering real-time air domain information in various forms and ways to the users that need it. Additional details about the role of NCO in Air Domain Awareness can be found in Chapter 5.

Using NextGen PNT services, routes and flight paths will no longer be constrained to fixed positions. Using complementary aircraft systems that provide required navigation performance and area navigation, PNT services allow aircraft to precisely navigate along the most efficient route that meets the needs of the user, the ANSP and the overall NAS. NextGen will be more flexible, responsive, and unconstrained using satellite-based and ground-based systems that provide universal PNT services that accurately and precisely determine current location, orientation, and desired path; apply corrections to course, orientation, and velocity in order to attain the desired position; and obtain accurate and precise time anywhere on the globe within user-defined parameters. With this information, aircraft can apply the necessary corrections to maintain a desired position and path.

Accurate and precise PNT services also enable improved surveillance capabilities, reduced separation standards, and the synchronized operations. The decommissioning of current ground-based navigation systems, along with the improved operations from enhanced PNT services, will result in significant cost savings. The NextGen vision requires Surveillance services that improve the accuracy, latency, integrity, and availability of surveillance information. Surveillance information is envisioned to be provided through a net-centric infrastructure, allowing all certified users including ANSPs, security providers, flight operators, and other COI the appropriate level of access to data in a secure manner. This improved precision, access, and timeliness of information will allow distributed decision making on a real-time basis during normal operations, abnormal events, or system-wide crises. NextGen Surveillance services will also provide many new functions, including full air situational awareness, en route de-confliction, and self-separation capabilities. Surveillance services will also reduce separation standards and provide precise 4DT information, including aircraft intent and conformance monitoring. Additionally, to minimize the risk of collisions and maximize the use of airspace, comprehensive tracking of aircraft and vehicles operating on the airport surface, within the ANSP responsible airspace, and in sovereign airspace will be provided, which would enable flexible assignment of multiple NextGen surveillance sources to any operational position at any time, and further allow more flexibility in assigning airspace to each position as needed to support distributed decision making. Surveillance services also will help provide adaptive flexible spacing and sequencing of aircraft on the ground and in the air.

5 Shared Situational Awareness Services

5.1 INTRODUCTION

Shared Situational Awareness (SSA) is fundamental to the Next Generation Air Transportation System (NextGen) vision for providing Integrated NextGen Information, Air Domain Awareness, and NextGen Weather Information. Integrated information sharing depends on availability of SSA information services. In turn, information services are dependent upon established infrastructure services. In short, information sharing is accomplished by the processes and applications that constitute the information services function. Another way to envision information services is to consider where authorized subscribers can access the information desired. This access can be accomplished in an automated and virtual fashion where subscribers produce a standing request for information using established protocols and standards. This access concept is what facilitates the NextGen vision of the future—distributed data for distributed decision making. The transformation of the air transportation system is dependent upon accessible and shared information.

As shown below, the NextGen Provide Integrated NextGen Information capability will provide shared situational awareness and enable authorized stakeholders to provide, discover, and consume timely and accurate NextGen relevant information (e.g., weather; surveillance; positioning, navigation, and timing (PNT); aeronautical; and geospatial) in a decentralized, distributed, and coordinated environment. Through available enterprise services provided by Net-Centric Operations (see Chapter 4), an environment is available where trusted aviation stakeholder partnerships, and aligned data policies and standards (which includes data conflict resolution) are provided to enhance decision making by dramatically shortening decision cycle times and improving situational awareness. The remaining sections in this Chapter describe the vision of NextGen Net-Centric Operations (NCO) and how it relates to shared situational awareness.

Provide Integrated NextGen Information: Integrated NextGen information provides authorized aviation stakeholders timely, accurate, and actionable information (e.g., weather, surveillance, aeronautical information, operational and planning information, and position, navigation and timing information) to shorten decision cycles and improve situational awareness using a net-centric environment managed through enterprise services that meets the information exchange requirements of the NextGen stakeholder community.

5.2 PROVIDE INTEGRATED NEXTGEN INFORMATION

5.2.1 Integrated Surveillance Information

The federal government conducts surveillance operations to detect, validate, and characterize cooperative and non-cooperative air vehicles in and approaching the National Airspace System (NAS). Interagency partners, working as a team, need to improve how they ensure safe, secure, and efficient passenger and cargo operations in the NAS while deterring, preventing, warning, and—if required—defeating unauthorized and unwanted air activities. They can do that through better integration of activities.

Key attributes of the underlying strategy to improve surveillance capabilities include: (1) maximize coverage of airspace from surveillance assets, (2) maximize sharing of surveillance data and other relevant information through machine-to-machine interface and other techniques to reduce redundancy of action, minimize surveillance gaps, and ensure data accuracy between interagency partners, and (3) correlate and fuse disparate data to ensure interagency mission partners are able to display, discuss, and act on the same track regardless of specific system interface and display properties. Additionally, through advanced processing and utilization of net-centric information management services, mission partners should, within the limits of U.S. policy and law, be able to: (1) automatically confirm when they are looking at the same track, (2) access pre-flight information in a timely manner, (3) receive automated, in-flight updates on changes in key flight characteristics, and (4) operate with increased confidence as a result of enhanced and shared track monitoring.

5.2.1.1 Shared Information

Varied levels of integrity of shared surveillance information are necessary, depending on the desired use of the information. Situational awareness and wide area surveillance requirements differ from safety of life and weapons targeting information. Some of the following characteristics are needed:

- **Provenance**. The validity of the original data source and the chain of custody of subsequent processing of the data are known.
- **Confidence.** The accuracy of original and transformed data must meet established thresholds of confidence.
- **Access control.** Dissemination of data and information must be appropriately secure and in compliance with policies, laws, directives or other regulations. Access to information must be based on appropriate processes, such as roles based access controls, and with the necessary need to know.
- **Consistency.** Algorithms for processing and analyzing data must meet standards for consistency among mission partners (e.g., tracker, coordinate system, and adaptation) to allow for shared situational awareness and collaborative decision making.
- **Availability.** A measure of the data present or ready for immediate use over time.
- **Accuracy.** The data represents the actual value of the quantity being measured.

- **Continuity.** Measure of the time between data points.

In addition to surveillance sensor data and existing information sources, shared information includes flight intent and intelligence information. Information from maritime domain awareness and space domain awareness, and potentially unmanned aircraft systems (UAS), could also be available for sharing.

5.2.1.2 Enabling Technologies

Refined, integrated aviation surveillance and geographic data are used by the public and by government Command and Control (C2) facilities providing Air Traffic Management (ATM) security, defense, and other shared services. SSA among government partners is enabled by both access to shared air vehicle track data and SSA data management services, and by the ability of C2 systems to publish and subscribe specific track and geographic air domain information. Net-centric data distribution capability and service-oriented, aviation surveillance data exchange protocols, developed by the aviation surveillance and intelligence communities of interest (COI) are fundamental enabling technologies for NextGen aviation surveillance services.

5.2.1.3 Sensor Network

As described in Chapter 4, *Net-Centric Operations*, a network centric infrastructure will deliver sensor data to facilities for subsequent automated processing. This network will have the appropriate class of service attributes, quality of service, and communications protocols for delivery of the near-real-time sensor data. The network will protect information in an appropriately secure manner. The outputs of existing federal surveillance sensors that are not currently integrated will be connected to the network as appropriate to take maximum advantage of their collective capabilities.

5.2.1.4 Shared Services

Automated processing of sensor and other surveillance relevant information will occur through shared services that provide for correlation, tracking, fusion, data reduction and other surveillance specific transformations. Services will also be provided that are of a more general nature, such as information discovery and translation. The services will be accessible through an enterprise network infrastructure. The specific identification of the shared services will be developed through the follow-on architecture effort.

5.2.2 Positioning, Navigation, and Timing (PNT) Services

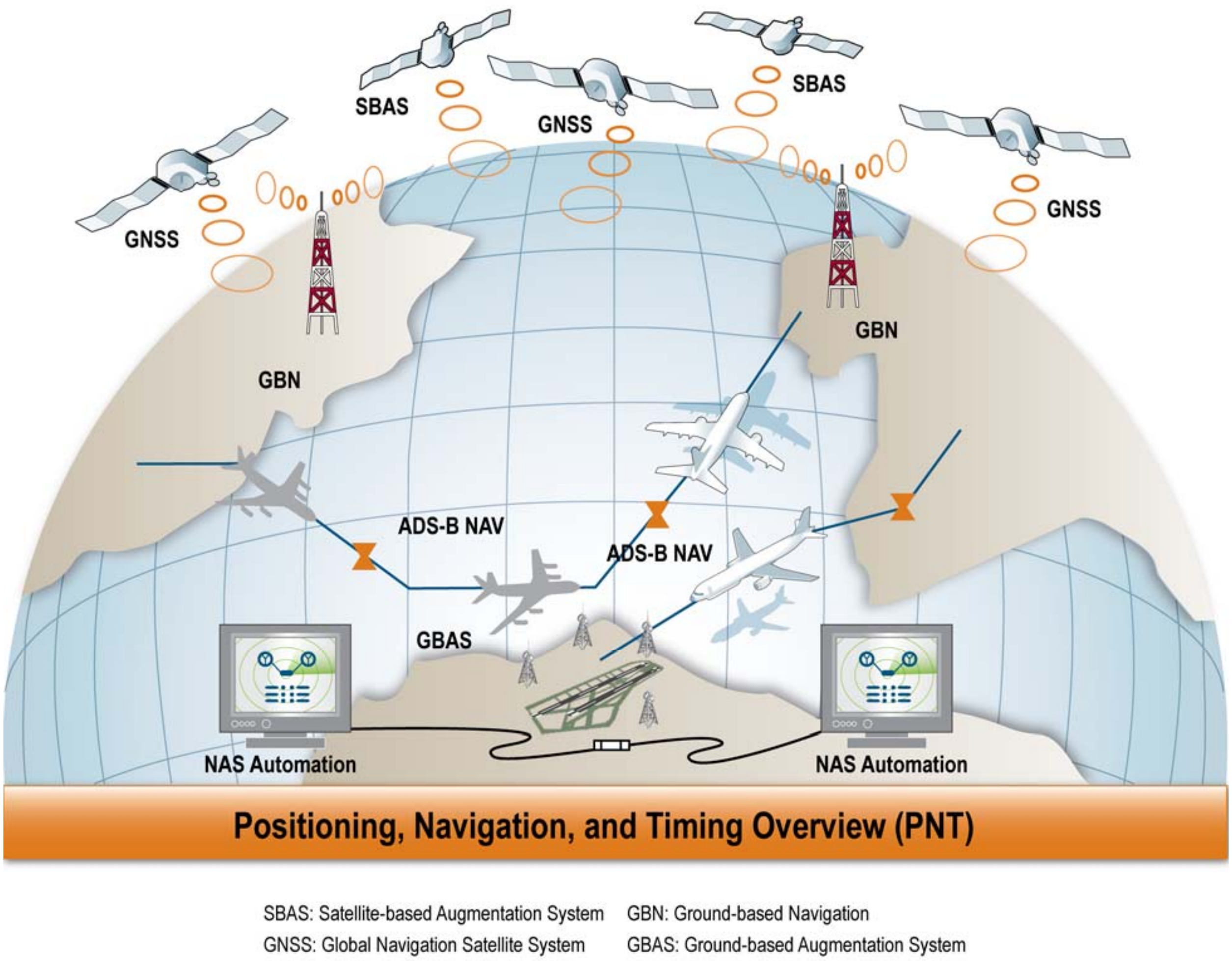
PNT Services are a key component of the shared situational awareness NextGen vision. PNT services will provide the ability for an air object to accurately and precisely determine its current location and orientation and its desired path and position; apply corrections to course, orientation, and speed to attain the desired position; and obtain accurate and precise time anywhere on the globe, within user-defined parameters. As illustrated in Figure 5-1, NextGen will rely heavily on PNT Services to implement and conduct many of the basic operations, including trajectory-based operations and time synchronization.

PNT services provide the fundamentals for navigation. Aircraft navigation has long been constrained by the capabilities of ground-based navigational aids (NAVAID) and routes that are

tied to the physical location of these NAVAIDs. Historical reliance on ground-based NAVAID locations has also constrained airspace design. In NextGen, PNT Services enable area navigation (RNAV) as the standard method of navigation in the NAS. Further, PNT Services provide the foundation for performance-based navigation operations, including those operations that have a specified required navigation performance (RNP) requirement. Note that performance-based RNP operations will vary based on airspace class to safely achieve operational objectives.

PNT Services enable enhanced aircraft surface operations, allowing aircraft to maintain separation from other aircraft, fixed infrastructure, and the various mobile elements of ground support equipment (GSE) found in the airport environment.

Figure 5-1 Positioning, Navigation, and Timing Overview



NextGen PNT Services are ubiquitous. They enable operations at remote and sparsely equipped facilities that in today's NAS are currently incapable of being performed without the purchase and continuous maintenance of additional costly ground-based NAVAIDs.

Finally, airspace design, including dynamic boundary and special use airspace, can more readily be developed based on operational needs and geographic and environmental limitations, rather than the placement of ground based NAVAIDs.

5.2.2.1 Timing Services

PNT Services provide a common, accurate, and precise timing source for all users from a standard universal coordinated time. These timing services enable the precise synchronization of operations and the reduction of uncertainties associated with disparate timing sources.

As NextGen moves toward a more net-centric approach to information dissemination among all stakeholders, the need for precise timing services becomes inescapable. Air-to-air, air-to-ground, and ground-to-ground systems all require precise timing in order to communicate and exchange information.

5.2.2.2 PNT Components

The primary system providing PNT Services in NextGen is expected to be a global navigation satellite system. Users may also have operational needs that require a satellite-based augmentation system, such as the wide area augmentation system (WAAS), or a ground-based augmentation system, such as the local area augmentation system (LAAS), in order to fulfill their requirements. These systems provide increased accuracy, availability, and integrity to users of the service.

Legacy navigation systems such as Distance Measuring Equipment (DME), Very High Frequency Omni-Directional Radio Range (VOR), and Non-Directional Beacon are incapable of meeting most of the positioning and navigational requirements of NextGen, and none of the timing requirements. It is likely that these systems will have been divested, either through decommissioning or through release to state and local authorities, or private entities, who desire to maintain such a capability for local airport use.

5.2.2.3 PNT Backup

A loss of PNT services, due to either intentional or unintentional interference, in the absence of any other means of navigation would have varying negative effects on air traffic operations. These effects could range from nuisance events requiring a systematic restoration of capabilities, to an inability to provide normal air traffic control service within one or more sectors of airspace for a significant period of time. Although procedural separation methods would be used to maintain safety of flight, several solutions have been identified that could help mitigate the effects of a PNT service disruption:

- Maintain a minimal network of VOR, DME, and Instrument Landing System (ILS) facilities
- Implementation of the Global Positioning Systems (GPS) L5 civil frequency to mitigate the impacts of solar activity and unintentional interference
- Modernized avionics that include inertial navigation systems
- Integrated GPS/inertial avionics anti-jam capabilities

- User equipage of Instrument Flight Rules-certified eLoran and Satellite Navigation receivers

5.2.2.4 PNT Summary

Nearly every aspect of NextGen requires PNT services. Flight planning, aeronautical information services, air navigation services, flight information services, geospatial information services, weather information services, and surveillance all require high levels of precision and integrity from the provisioned PNT service of NextGen. With PNT Services, a user (or COI)-determined integrated air picture provides SSA to all NextGen users.

5.2.3 Aeronautical Information Services

In NextGen, aeronautical information is uploaded, received, aggregated, and exchanged with accuracy and in a timely manner. Subscribers to the system include flight operators, airport operators, air navigation service providers (ANSP), and other stakeholders. Aeronautical Information Services include updates and aggregated information on:

- Current performance requirements for airspace access and operation
- Special-use airspace status and activity
- Airspace affected by temporary flight restrictions
- Route information and performance metrics
- System outages affecting GPS, WAAS, LAAS, and other NAVAIDs
- Weather status, such as convective activity, winds aloft, and icing
- Airport status information, including runway availability and planned long- and short-term activities affecting the airport, such as construction and snow removal
- Definitional data for airspace boundaries, fixes, terminal procedures, runways, and other supporting information

The system accepts information from both ground and airborne users, aggregates the information, and makes it available to subscribers. Updates to aeronautical information are performed in real time and provided in a manner that allows users to readily understand the changes. The information is user-friendly and available in digital form (graphically or via digital text). The data is also machine readable and supports automated processing of information for trajectory-based operations (TBO).

Aeronautical Information Services utilize Geographic Information System (GIS) to provide users with the ability to access and update information about the physical locations of both fixed and mobile assets within NextGen. This service provides information on such assets as physical facilities, airspace boundaries, airport survey information, and the locations of communications, navigation, and surveillance (CNS) infrastructure elements. To achieve this level of information exchange, all assets in the NAS are described in a common reference set (i.e., an earth-based

coordinate system) to ensure comparability and interoperability across all applications. Further, to increase the efficiency of these comparisons, GIS users can employ a common indexing structure to support the asset information development and exchange of information as well as query about overall asset inventories. The GIS manages current information, maintains historical information, and allows access to planned/desirable future capabilities. Under this structure, static elements (e.g., sectors, fixes, NAVAIDS, and radars) and dynamic elements (e.g., aircraft, weather, and temporary flight restrictions) are referenced to latitude and longitude, then indexed to a single hierarchical grid to speed comparisons. The design of the index supports high-resolution data and includes the temporal (time) component necessary for projections and strategic planning. This capability supports the reconfiguration of airspace and airport assets to provide maximum use of the available capacity to meet traffic volume, while adjusting for weather or other constraints as they arise.

The GIS supports dynamic airspace boundary adjustments, TBO, interactive flight planning, and future decision support tools operating in a collaborative environment of shared data. This service depends on the ability to describe, communicate, and manage the characteristics of airspace and other asset information (and their constituent elements) at increasingly finer levels of resolution. This increased precision and resolution supports decision making by the ANSP as well as provides a basis for SSA for collaboration (such as cooperative ATM) among the ANSP, flight operators, and other stakeholders in NextGen.

5.3 PROVIDE INTEGRATED AIR DOMAIN AWARENESS

Effective operation of the national air transportation system—for civil aviation, national defense, homeland security purposes, and other aviation security activities—relies on accurate and timely airspace situational awareness. As described in Section 5.2, to meet national objectives, the federal government conducts surveillance operations to detect, validate, and characterize cooperative and non-cooperative air vehicles in and approaching the NAS. Interagency partners, working as a team, need to improve how they ensure safe, secure, and efficient passenger and cargo operations in the NAS while deterring, preventing, warning, and—if required—defeating unauthorized and unwanted air activities.

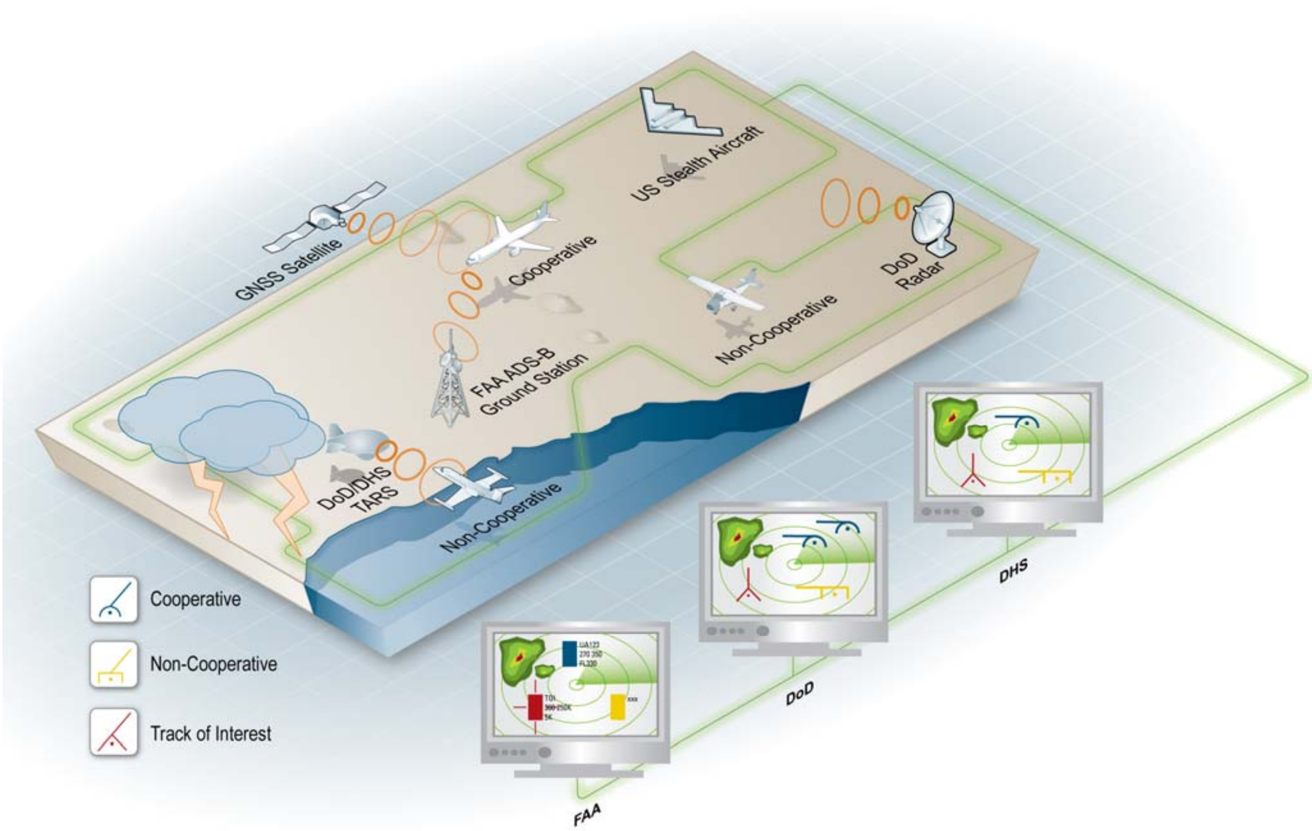
As illustrated in Figure 5-2, multiple departments and agencies have a need for aviation surveillance information to satisfy their often overlapping aviation-related roles and responsibilities. These agencies and their associated needs include:

- Department of Transportation/Federal Aviation Administration (FAA) for providing separation services in the NAS and supporting aviation security
- Department of Homeland Security (DHS) for providing airborne and airport aviation security
- Department of Defense (DoD) for defending airspace, executing air sovereignty and air defense missions, and for civil support and catastrophic event mitigation
- Office of the Director of National Intelligence, on behalf of the intelligence community, for integrating all-source intelligence and supporting integration of intelligence and surveillance data to enable shared domain awareness among interagency partners

- Department of Commerce for NAS surveillance and atmospheric information to generate weather forecasts and information on routine and hazardous weather

The overlapping roles of these agencies create cross-dependencies among those who need to make use not only of the surveillance information produced by their own surveillance systems but also data produced by systems owned or operated by other agencies. All agency partners can benefit from technologies that increase availability and management of high-quality surveillance data, including: common data fusion, computer-assisted anomaly detection tools, common data standards, data exposure and sharing, and a tailorable user-defined operational picture.

Figure 5-2 Surveillance Overview



5.3.1 Coordinated Security

Changes to the way federal, state, local, and tribal government agencies will use and share information under NextGen are aligned with the guiding principles of the National Strategy for Aviation Security (NSPD 47/HSPD-16), which recognizes data integration and information sharing capabilities as central pillars of air domain security.

The Air Domain Surveillance and Intelligence Integration Plan specifically names detection, information sharing, and integration as guiding principles. These guiding principles inform the operational concepts for integrated air surveillance, which encompass:

- **Informing** through the aggregation of all available flight-related information
- **Monitoring,** in service of both air traffic safety and preserving the security, the NAS
- **Detecting** planned or actual anomalous and/or suspicious behavior within and approaching the NAS
- **Identifying and Locating** safety and security threats to the air domain
- **Assessing and Responding** to identified safety, security and defense threats

National Strategy for Aviation Security

"*The Nation must refine ongoing efforts to develop shared situational awareness that integrates intelligence, surveillance, reconnaissance, flight, navigation systems, and other aeronautical data and operational information. To ensure effective and coordinated action, access to air domain awareness information must be made available at the appropriate classification level to agencies across the U.S. Government, other local government actors, industry partners, and the international community*."

5.3.1.1 Detection

The FAA is envisioned to continue to maintain DoD/DHS-funded primary radar devices and tracking systems as well as its own Primary Surveillance Radars in terminal airspaces. DoD, DHS, and FAA will continue to rely on these as a primary, but not sole, source for detecting anomalous and suspicious behavior, especially for non-participating or non-cooperative aircraft. The FAA would increasingly rely upon Automatic Dependent Surveillance-Broadcast (ADS-B) out for air traffic management of commercial aircraft operating within the NAS. The increased accuracy of these ADS-B tracks provides significant benefits to equipped users through improved efficiency and priority handling. It also will eventually help support reduced separation standards for equipped aircraft and implementation of an automated system for detecting anomalous activity and alerting air traffic control operators and security partners of such activity. ADS-B tracking capabilities and long- and short-range surveillance radars, when combined with continuous, automated updating of ATM flight information and DHS risk assessments, will assist DHS, DoD, and law enforcement agencies to quickly and confidently identify friendly participating commercial aircraft, thereby providing support for actions in response to unauthorized or suspicious aircraft operating within or entering into U.S. airspace.

5.3.1.2 Information Sharing

Automation of many of the information exchanges that today must be handled through labor-intensive, time-consuming verbal or written communications or by manual data integration achieved through repetitive querying of multiple, incompatible databases will not only speed up ATM and air domain security decision-making processes, but will increase the confidence with which decisions are made. ANSP, for instance, will have immediate access to any change made by DHS to a flight's risk profile, enabling its operators to quickly and confidently assess the status and intent of most flights within controlled airspace. Shared, automated, and immediate access to all pertinent pre-flight information and continuous, real-time aggregation and correlation of data feeds from surveillance systems will likewise provide DHS with the information it needs to eventually make an accurate assessment of the security risk of any given flight.

5.3.1.3 Integration

For civil aviation and security and defense operations, the integrated aviation surveillance services have to be anchored on three fundamental principles: 1) maximizing operational benefits for all mission partners, 2) ensuring safe, secure, and efficient operations in the NAS, and 3) harmonizing global aviation to freely move passengers and cargo. For civil, security, and defense operations, the size of the target, speed, radar signature, and whether the vehicle is manned or unmanned must be taken into consideration. Weather affects airborne operations and response; therefore, weather information must be incorporated accordingly. Accurate and timely aviation surveillance information, both cooperative and non-cooperative, is also crucial for efficient air traffic operations, and for threat detection and assessment. Aviation surveillance is at the intersection of several key capabilities, such as precision PNT, CNS, TBO, and four-dimensional (4D) aircraft operations. The integrated aviation surveillance service will improve the ability and allowable time to support effective operational decisions for all mission partners for all surveillance-related operations, including ATM and security and defense operations.

5.3.2 Domain Awareness

The NextGen emphasis on safety means that air domain situational awareness, and consequently, improvements to air surveillance information management, will be crucial to the success of the NextGen program.

The *National Strategy for Aviation Security* and the supporting *Air Domain Surveillance and Intelligence Integration Plan* offer similar guidance, noting that "to maximize domain awareness, the Nation must have the ability to integrate surveillance data, all-source intelligence, law enforcement information, and relevant open-source data from public and private sectors, including international partners." These documents direct partner agencies to synchronize surveillance efforts and integrate capabilities to persistently monitor, detect, identify, and track aerial objects within and outside the United States.

In the NextGen integrated surveillance environment, data from all surveillance sources, including cooperative and non-cooperative systems data, will be accessible and made available/exposed for operational display and data processing. Moreover, integration of surveillance information from multiple sources, including classified systems, will provide real-time access to the information needed to deter and prevent threats before they enter U.S. airspace; to identify, locate, assess and respond to threats that originate within U.S. airspace; and to conduct routine air traffic operations in a manner that supports both increased air traffic and increased flight safety.

Today, much of the information needed to achieve the level of air domain situational awareness envisioned for NextGen is already being collected and stored, but the disparate databases in which this information resides are largely incompatible. Thus, the information accessible to one security partner may be inaccessible to the others. The intent of the net-centric environment and the power of enabling user-defined operational pictures is that each mission partner will be able to access, share, and display the data needed to most effectively execute the mission, even though they may not be the producer of the data they use and display. Air domain situational awareness is achieved through access and exposure to multiple data sources and composite

information fusion enabled by machine-to-machine interfaces and rapid data push/pull capabilities.

NextGen data integration and information sharing capabilities “will transform today’s incompatible databases scattered throughout government and industry into a proactive safety analysis tool.[11]“ Aviation surveillance source data will be integrated, shared, and monitored by collaborative, mission-specific systems that will automatically detect and alert air domain security partners to the occurrence of anomalous activity in the NAS. Surveillance data will be augmented with other mission-related data such as air vehicle flight plans, clearances, risk levels, weather forecasts, and intelligence, which will be readily accessible through NextGen net-centric, information sharing services. Fusion of surveillance data and machine-to-machine interfaces will facilitate efficient and accurate coordination between operators, and reduce the cost by optimizing communications paths and reducing redundancy.

Collectively, this provides air domain awareness: the ability of aviation partners to share and access near-real-time information relevant to threat identification, monitoring, prevention, and response, based on net-enabled, shared situational awareness that informs risk-based decision making.

5.4 PROVIDE INTEGRATED WEATHER INFORMATION

Under this concept of operations, the primary role of weather information is to enable the identification of optimal trajectories that meet the safety, comfort, schedule, efficiency, and environmental impact requirements of the user and the system. Weather information is not just an end product to be viewed in a stand-alone display. Rather, weather information is designed to integrate with and support NextGen decision-oriented automation capabilities and human decision-making processes.

Weather information in the form of meteorological variables that are observed or forecasted (e.g., storm intensity, echo tops) must be translated into information that is directly relevant to NextGen users and service providers, such as the likelihood of a flight deviation, airspace permeability, and capacity. This information is supported by a set of consistent, reliable, probabilistic forecasts, covering location (three-dimensional space), timing, intensity, and the probability of all possible outcomes, each with an associated likelihood of occurrence.

Today, weather information is drawn from numerous sources. In NextGen, consistency and continuity in the common weather picture are ensured by centrally managed weather information that is distributed by the government through the NextGen Network Enabled Weather (NNEW) “virtual database” capability. The reliable, virtual common weather picture concept means, for example, that information on convection for a geographic area, developed by different forecast models and in different databases, is arbitrated or merged into a single forecast that all requesting users receive. NNEW weather observations and forecasts are the primary source of weather used in joint government/user NextGen decision-making processes. NNEW represents the Network-Enabled Operations (NEO) vision of a “weather channel” in keeping with the NextGen

[11] NGATs Integrated Plan, 2004.

information sharing policy. Today's complex and costly architecture of point-to-point connections to weather sources is replaced by a single-access approach for all users.

At the core of the NNEW capability are 4D weather sources referenced to position and time, formed by automated processes through merging observations, models, climatology, and human forecaster input. The information is available to generate displays and for direct integration into automated decision support systems. The 4D weather capability provides the basis of the common picture and consists of weather attributes organized by horizontal, vertical, altitude, time, and probability components (x, y, z, t, plus probability). Observations from surface sources, aircraft, and satellites are incorporated into the common weather picture.

The update frequency of this weather information is commensurate with the need to react to unanticipated, rapidly changing circumstances. For instance, airspace structural changes are better customized in response to changing weather conditions (e.g., realigning sectors to conform to a line of thunderstorms). Also, the NextGen weather capabilities allow rapid notification (automation-to-automation) of changing weather situations to strategic and tactical NextGen decision makers.

As with enhanced communication of weather information to ground-based automation systems and human users, weather data communications to the flight deck involve both "subscribe" and "publish" dissemination of critical information. Aircraft may request ("subscribe to") specific weather information impacting their flight route, while broad area weather advisories and warnings are issued ("pushed") to all affected aircraft when safety-critical changes occur.

Under NextGen, network-enabled aircraft also become active participants in collection and transmission of weather information; observations are transmitted to ground-based systems for integration with other weather sources and to other aircraft. Aircraft operating in performance airspace act as fully enabled operational nodes on the NEO information grid. Aircraft contribute observations for localized now-casts and receive them via data link; they also provide critical in situ observations for use by nearby aircraft. UASs are used for making in situ observations, performing weather reconnaissance missions such as scouting for favorable routes and collecting critical observations where and when needed, and collecting ionospheric data and radiation activity originating from space weather.

5.4.1 Weather Information Operations

Under the direction of decision support systems, NextGen weather services provide information to stakeholders. Procedural ANSP processes, user-automated processes, and NextGen decision support systems use the common weather picture, including probabilities, to facilitate collaborative decision making. NextGen decision support systems use a risk management approach in planning Capacity Management and Flow Contingency Management options. The use of the common weather picture is a primary basis for collaborative NextGen decision-making purposes (e.g., flow planning), but other commercially available, value-added weather sources may be used by stakeholders in making their own flight-planning decisions (e.g., determining what preferred flight paths they will request). In developing the NextGen common

weather picture, the government may choose to acquire commercially developed weather products and capabilities for inclusion in that common picture.

Weather information is tailored to the operational needs of those interested parties, maintaining a consistent view of weather information. For example, if multiple stakeholders are looking at levels of convection for a geographic area, the locations and intensity of the convection are the same. This tailoring of weather information is enabled by maintenance of a common weather picture at different resolutions, time scales, and geographic areas (e.g., the information for an airport is at a higher resolution and more rapidly updated than that for adjacent oceanic locations). Pre-flight and in-flight decisions are aided by weather services that assist the user in making tailored inquiries into the common weather picture. Other weather information such as alerts, advisories, and warnings regarding significant weather changes are proactively published to stakeholders via digital communications. For example, the flight deck receives key weather updates along the route of flight, thereby enhancing dynamic decision making and flight safety. Weather Information Services functions are highlighted and discussed below:

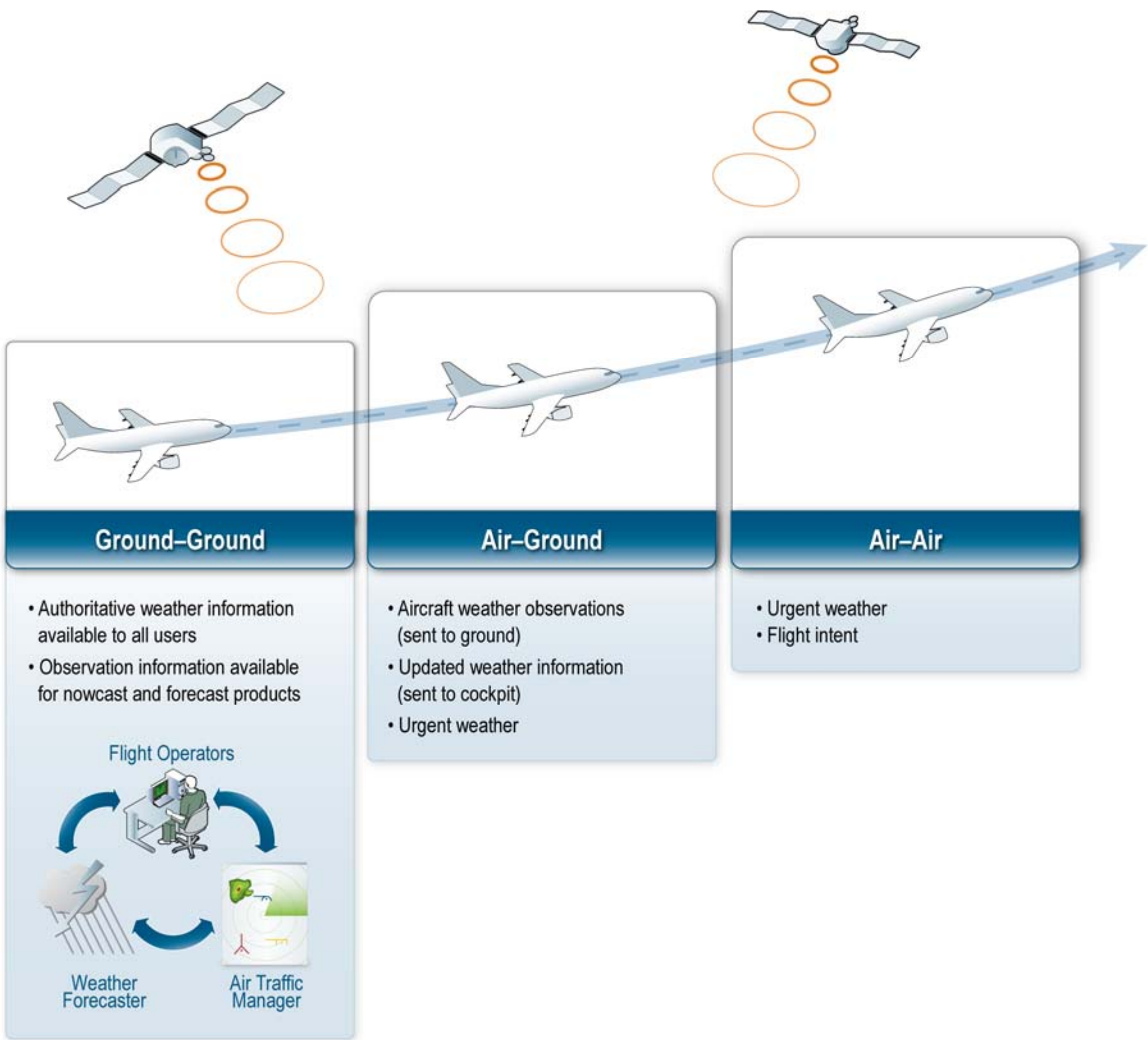
- **Aircraft Are Capable of Receiving, Collecting, and Transmitting Weather Information as a Digital Data Stream**. Fully capable aircraft have the appropriate automation (communication and computing) systems to receive weather data (including hazard information) and to transmit sensor data, which will be provided to the NNEW. Fully capable aircraft are able to collect and integrate weather information into onboard displays and weather-mitigating operational flight programs.

- **Hazardous Weather Is Identified in Real Time**. NNEW uses ground-based, space-based, and airborne sensors and systems to provide timely, relevant, accurate, and consistent hazardous weather information to aircraft and users in near-real-time. Automation of traditional observations (e.g., pilot reports) facilitates improved hazardous weather identification.

- **Observation and Forecast Are Provided for Non-Towered and Virtual Towered Airports**. NNEW provides current and forecast weather information from the common weather picture to non-towered and virtual towered airports at the required spatial and temporal resolution. Hazardous weather in the terminal area that impacts departures and arrivals is forecasted and also detected in real time.

- **NNEW Provides the NextGen Decision-Oriented Tools (NDOT) with Trajectory-Based Weather**. NNEW provides the NDOTs with trajectory-based weather information that is aligned with flight planning and ATM. Trajectory-based weather information (observations, forecasts, model/algorithm data, and climatology, including surface observations and weather aloft) allows full integration of weather into traffic flow decision making. NNEW allows the NDOTs to identify weather-impacted airspace (both real-time and forecasted) as reduced-capacity and as no-fly airspace. NNEW provides the NDOTs with climatology (to permit up to at least a three-month pre-flight planning window) and provides probabilistic forecasts to allow for multiple preplanned trajectories and airspace configuration scenarios. An example of weather information operations is shown in Figure 5-3.

Figure 5-3 NextGen Weather Dissemination Foundation for Net-Enabled Weather Operations



5.4.2 Weather Information Enterprise Services

Decision making by the diverse set of NextGen stakeholders is facilitated by an integrated, common picture of the weather situation. In general, stakeholders do not need meteorological expertise to interpret weather information. In addition, net-centric weather services tailored to the user's needs reduce or eliminate the requirement for stakeholders to manually gather, interpret, and integrate diverse and sometimes conflicting weather data to realize a coherent picture of the weather situation; instead, this is achieved with automation assistance prior to dissemination. Decisions are predictable when stakeholders use an understandable common weather picture as a source and apply the same business processes.

A central enabler for this weather capability is access to a reliable, virtual common weather picture. This common picture for current and forecast weather information includes weather attributes organized by horizontal, vertical, altitude, time, and probability components (i.e., 4D

plus probability). Optimal air transportation decision making mitigates the risk of conflicting courses of action by requiring a single reliable NextGen common weather picture. NextGen weather data is collected, processed, forecast-fused, and distributed through a service-oriented architecture-enabled government weather information capability. The underlying premise is that the various weather data are consistent. Therefore, everyone looking into the weather information portal from the same aspect (point of view in terms of weather attributes) sees a common weather picture. However, the picture may vary on how the information is rendered (e.g., text, audio, graphics, imagery, polygons); thus, a reliable, virtual common weather picture is provided. Furthermore, the weather source is not a single database but rather a network of information sources accessed via net-centric weather services, reinforcing the "virtual" concept. Moreover, net-centric enterprise weather services reduce stakeholder operational costs by eliminating expensive, customized, point-to-point interfaces from user systems to multiple sensors and sources. The services comprise:

- **Multiple Weather Observations and Forecasts are Fused into a 4D Common Weather Picture That is Distributed through NNEW.** Weather data (observations, forecasts, model/algorithm data, and climatology) are integrated into a common weather picture (Earth's surface to low Earth orbit is used in all weather-oriented decision processes). Weather observations are contained in NNEW and used by forecasting tool sets to produce forecasts (both routine and aviation impacting) for all users. Users retrieve weather information needed for decision making in real time from NNEW. Vendors may use information from NNEW to produce tailored, value-added products for use in and out of the cockpit. Some weather information, such as turbulence and icing, is also tailored to the airframe as well as the route. This capability depends on NNEW to disseminate a common weather picture in support of NextGen. Weather information is also used to help evaluate environmental impacts from increased aircraft operations, such as increased noise and exhaust emissions at and near airports and in volumes of airspace that may be particularly sensitive to aircraft exhausts.

- **Weather Sensors are Included in Performance-Based Services.** Fully capable aircraft have a standardized set of weather sensors/algorithms to provide weather data to other users directly and via NNEW. Weather data from aircraft are valuable inputs to the common weather picture for providing advice and warning to nearby aircraft and for providing input and verification for weather forecast products. At a minimum, in addition to accurately providing their 4D geospatial position, aircraft provide in situ wind, temperature, water vapor, turbulence, and icing information. Aircraft may also measure non-weather parameters (e.g., volcanic ash), use forward- or downward-looking remote weather sensors, and carry dosimeters to measure the radiation environment that is affected by space weather activity.

- **UASs are Used for Weather Reconnaissance.** En route weather reconnaissance UASs are equipped to collect and report in-flight weather data. Specialized weather reconnaissance UASs are used to scout potential flight routes and trajectories to identify available "weather-favorable" airspace. UASs may also carry instrumentation to measure the radiation environment that is affected by space weather activity.

6 Layered, Adaptive Security Services

6.1 INTRODUCTION

This Concept of Operations (ConOps) for the Next Generation Air Transportation System (NextGen) describes an effective security system that does not unduly limit mobility or make unwarranted intrusions on the civil liberties of users and employees by embedding layered, adaptive security measures throughout the air transportation system, from reservation to destination. The NextGen security services framework consists of an overarching Integrated Risk Management (IRM) system, providing informed decision making and adaptive risk mitigation strategy to securing people, airports, checked baggage, cargo and mail, airspace, and aircraft. The NextGen Security Services concept addresses:

- IRM
- Secure people
- Secure airports
- Secure checked baggage
- Secure cargo/mail
- Secure airspace
- Secure aircraft

The security system has particularly strong interrelations with NextGen shared situational awareness (SSA), airports, Air Traffic Management (ATM), safety, aircraft, and global harmonization capabilities. This chapter provides an overview of the NextGen Layered, Adaptive Security Services; for a detailed look at specific aspects of this system, see the NextGen Layered, Adaptive Security Services Annex (http://www.jpdo.gov/library/NextGen_Security_Annex_v2.0.pdf).

Layered, adaptive security is defined as a risk-managed security system that depends on multiple technologies, policies, or procedures that are adaptively scaled and arranged to defeat a given threat or threat category. This adaptability further permits the use of increased variability in security system operations that creates more uncertainty for the terrorist. Adversaries cannot defeat one particular security measure and thereby achieve a “break-through” to operate freely with no further barriers to their activities. Furthermore, the security system has the adaptability to scale its resources, systems, and procedures to the risks level of a threat in a given situation, rather than being bound to an inflexible “one size fits all” approach.

Given the limited resources of both the government and private industry, it is critical that mitigation measures are developed based on threat and vulnerability as well as the potential consequences to individuals, critical national assets, significant events/activities, and the

economy. The NextGen approach matches system investments and resources allocation with the risk assessment and the capacity demands at various segments of the air transportation system.

To achieve the requisite adaptability while maintaining effective security standards, the NextGen security system must have a sound method of prioritizing risks and assessing the proportional effectiveness of different ways of countering them. The Secure IRM process performs this essential function that then directs the deployment of equipment, personnel, and procedures/policies to defeat the evolving threat. The remaining capabilities described at a high level in this chapter are the result of IRM assessments.

6.1.1 NextGen Security Management and Collaborative Framework

NextGen Security is a shared mission among many stakeholders. The NextGen Security System is optimally integrated with other National Airspace System (NAS) functions, and through advanced networking functionality, linked to external aviation industry stakeholders and non-federal government entities. To maintain effective security management across major stakeholders, a collaborative framework is composed of the following key functions and processes:

- **National Aviation Security Policy.** NextGen Security Policy embraces a broad view of threats, including direct attack, exploitation, and transfer; recognizes interdependencies and uncertainty; nurtures virtual or extended enterprises supported by connectivity of diverse, informed stakeholder partnerships; employs layered security using physical, process, and institutional layers; accounts for systemic vulnerabilities that are created by the networked nature of the aviation system; and creates an environment that facilitates a rapid, seamless return to normal business operations subsequent to an incident. NextGen has achieved integration with the overarching Homeland Security Presidential Directives and their subsidiary documents.

- **Aviation Security Stakeholder Involvement.** NextGen Stakeholder Involvement fosters industry, federal, and local partnerships with clearly defined roles and responsibilities for prevention, protection, response and mitigation, and recovery operations at strategic, operational, and tactical levels. Collaborative decision making contributes to a positive security culture. Timely, effective, and informed decision making based on SSA is achieved through advanced communications and information sharing systems.

- **Aviation Security IRM.** NextGen IRM includes prognostic tools, models, and simulations at the strategic, operational, and tactical levels, including nominal and off-nominal situations, to support all stakeholder decision makers and managers with incorporating cost-effective best practices into the design, acquisition, deployment, and operation of aviation security system assets and infrastructures. Knowledge bases concerning threats, vulnerabilities, and practices are tailored to user profiles that proactively determine need/authorization to know.

- **Aviation Security Implementation.** NextGen Implementation capabilities encompass a robust set of strategic, tactical, and operational capabilities and services focused on

prevention, protection, response and mitigation, and recovery initiatives that are undertaken by a variety of stakeholder organizations.

- **Aviation Security Assurance.** NextGen Assurance capabilities include a variety of certification programs administered by federal, industry, and local stakeholders, surveillance and evaluation activities administered and performed by various stakeholders, enforcement inspections performed by federal and local stakeholders, and incident investigations performed and administered by various stakeholders.

The key transformations inherent in the NextGen Security concept described both in this chapter and in the supplemental Security Annex, provide new, significant security capabilities. As shown below, the NextGen security capability describes the transformations expected to occur in the areas of checkpoint operations responsibilities, credentialing/authentication, baggage screening technology, passenger screening, chemical, biological, radiological, nuclear, and high yield explosive (CBRNE) detection, and security system deploy-ability.

The NextGen Security Capability is supported by an IRM system, monitoring, assessing, and coordinating a variety of data and communications associated with flight objects and the users. IRM describes the NextGen security methodologies and practices designed to protect and secure people, airports, checked baggage, cargo and mail, airspace, and aircraft in the NextGen System. The transformed system will focus on the users (passengers, workers, and crew) by incorporating deployable systems to provide remote terminal security screening (RTSS); passenger and aviation worker pre-screening and state-of-the-art checkpoint systems to detect the threat; as well as cargo, baggage, and mail screening. In addition, the NextGen Security System will focus on reducing threats from terrestrial weapons threats (lasers, man-portable air defense shoulder-fired missiles or projectile weapons) and electromagnetic pulse weapons to the airframe through hardening and threat detection technology. NextGen Security will address threats to airports, commercial spaceports, piloted and unmanned aircraft systems (UAS), capturing risk to facilities and aircraft as a potential target or a weapon. With the aid of IRM, the system will allow for dynamic monitoring and management of security restricted airspace (SRA) and special use airspace (SUA) to allow for efficient and safe transit of vetted aircraft and to prevent the use of aircraft as a weapon against persons, critical national infrastructure, and significant events.

Provide Air Transportation Security: The capability to provide Air Transportation Security relies on the concept of layered, adaptive security based on risk assessment and risk management thus yielding the ability to identify, prioritize, and assess national defense and homeland security situations and appropriately adjust resources to facilitate the defeat of an evolving threat to critical NAS infrastructure and key resources using a collaborative approach (e.g., appropriate tactics, techniques, and procedures) without unduly limiting mobility, making unwarranted intrusions on civil liberties, and minimizing impacts to airline operations or aviation economics.

6.2 INTEGRATED RISK MANAGEMENT (IRM)

Risk management is the ongoing process of understanding the threats, consequences, and vulnerabilities that can be exploited by an adversary to determine which actions can provide the greatest total risk reduction for the least impact on limited resources. Risk management is inherent to every element of Layered, Adaptive Security Services; it is conducted from the strategic to the tactical levels. This chapter describes the strategic aspects of the IRM process. The following sections briefly mention the relevant tactical aspects of IRM for that particular threat vector. The NextGen Layered, Adaptive Security Services' IRM capability is an overall federated risk assessment and risk mitigation framework that guides multiple security service enterprises to assist in making decisions, allocating resources, and taking actions under conditions of uncertainty. This framework is a planning methodology that outlines the process for satisfying or exceeding security goals through prevention, protection, response and mitigation, and recovery. It satisfies the following needs:

- To understand the spectrum of threats that could be mounted against NextGen
- To identify the vulnerabilities that can be exploited by an adversary
- To evaluate and prioritize assets/activities to be protected from attack
- To determine which protective actions can provide the greatest total risk reduction for the least impact on limited resources
- To provide the most focused and adaptive security measures to reduce the impact of security systems and procedures on air transportation

IRM is characterized by a specific and consistent terminology to describe its various aspects. Threats are the likelihood of an attack on a particular asset. Vulnerabilities are weaknesses in the design, implementation, or operation of an asset or system that can be exploited by an adversary or disrupted by a natural disaster. Consequences are the result of an attack on infrastructure assets reflecting level, duration, and nature. Risks are measures of potential harm that encompass threat, vulnerability, and consequence.

The assessment of risks provides a prioritized list of vulnerabilities and potential mitigation strategies. Because the terrorist has the freedom to choose targets and modes of attack, the NextGen Security System must develop (but not necessarily universally deploy) operationally feasible mitigations to as many potential threats as possible. Because of limited resources, mitigation requiring substantial investment (e.g., system cost or infrastructure intensive) is applied (deployed) in the order of risk level. For example, external attacks on aircraft may be an issue at some airports requiring mitigation. This does not mean that all general aviation airports will have or need such systems.

Another way to effectively apply resources is through technical advances in sensor design and fusion as well as cost efficiencies typical of information processing system upgrades. With the development of low-cost CBRNE sensors for low-volume operations, it will be possible to conduct screening in 2025 at sites that are economically infeasible currently for a given risk

profile (thus permitting many more airports to provide commercial service). This does not mean that all non-commercial operations have to screen passengers or cargo for flights posing below-threshold risk levels. Many flights occur far from major metropolitan areas or national security restricted areas; however, flights to sensitive areas have to make adjustments to mitigate their risk profile.

In summary, it is essential to remember that the Security System responses and procedures throughout NextGen are applied based on the risk profile of each flight and airport facility. Facilities or flight objects that do not adopt particular security processes may still operate in NextGen but may have to observe some restrictions depending on the given risk profile created. Yet their overall access and performance in NextGen, even with some (self-imposed) security restrictions, is considerably greater than their current access.

6.3 SECURITY SERVICES

6.3.1 Secure People

The perception of a secure aviation system environment via publicly visible or implicit checkpoint and carry-on baggage screening operations is an extremely important tenet of the NextGen Security Architecture. Other less-visible security procedures may work toward similar ends and achieve them as effectively; however, the visible aspect of checkpoints and baggage screening is still the most tangible element to the general public and hence the most relied upon procedure in establishing the public's level of confidence and thereby their use of the system. The checkpoint displays an operating profile of consistency and routine, while behind the scenes it has several new screening techniques and tools that are brought to bear upon the assessed risk and, in some cases, performed randomly as an added measure.

In NextGen, the Secure People capability of the security architecture puts greater reliance on an integrated approach to correlate credentialing and identification processes with screening. Aviation security risks are mitigated by identifying people who, whether travelers or aviation workers, are a potential threat and preventing them from gaining access to the air transportation system through pre-screening/credentialing, screening, and intervention. For travelers, aviation security is provided continuously from the time the reservation is made until the safe arrival of the flight at the destination airport and the uneventful retrieval of baggage by the passenger. For persons with disabilities (PWD), the NextGen Secure People capability ensures accommodation and privacy by including special training and procedures for screeners, separate screening areas, and appropriate equipment to address PWD needs. For aviation workers, a standardized credentialing process; standardized, periodic updating and re-credentialing of secure access personnel; and identification technologies deny unauthorized individuals access to restricted areas of airports. The NextGen Network-Enabled Operations (NEO) permits more valid and faster credential verification. A balance between security and customer service is maintained, permitting the consistent, efficient, and seamless movement of passengers at the airport.

6.3.2 Secure Airports

The NextGen airport (as summarized in Chapter 3) has an integrated facility security system scalable to differing capacity, access, and risk environments. The Secure Airport ConOps

includes both technological and procedural measures to protect against the dynamically evolving threat. This flexible security system leverages advanced net-centric capabilities inherent in NextGen to minimize redundant credentialing and access controls while providing SSA when security incidents occur or credentialing concerns surface.

The NextGen Airport NEO seamlessly links sensors and data sources from access and screening checkpoints for passengers, visitors, employees and vehicles, perimeters, and critical facility infrastructure. The airport security technologies and adjustable procedures are nominally transparent to passengers and cargo, but hard to exactly predict by those who intend harm. Additionally, the NextGen airport has resident response and recovery programs enabled through local and regional memoranda of agreement and supported by the federal government. In this connection, the net-centric operations of NextGen maintain real-time connectivity to other regional airport operators, law enforcement, and government intelligence and Security Service Provider (SSP) operational entities. These Secure Airports Services, used with IRM tools, enable quick ramp-up response operations to incidents of national significance, including CBRNE attacks on the airport or within the region. The emergency response has been appropriately rehearsed to ensure that the responders are fully prepared and informed for any contingency.

The layered and overlapping security systems are in place at the following types of airport facilities:

- Commercial (passenger/cargo) airports
- RTSS facilities
- Public general aviation airports
- Commercial spaceports

The systems also are located at the following areas within the above listed facilities, as appropriate:

- **Airside.** Security identification display area/airport operations area, terminal perimeter, terminal airspace (security)
- **Landside.** Terminal public and commercial roadways and parking lots, terminal entry and departure, airline ticketing kiosk/counter, sterile area, international arrivals/customs, security control center, response and recovery operations

6.3.3 Secure Checked Baggage

This section includes printing bag tags at remote locations for airport check-in. This section also includes provisions for RTSS to allow passengers to undergo full screenings at off-airport locations and then be transported directly to the sterile area of the airport terminal while their screened, checked bags are taken directly to the aircraft. The screened baggage is available for direct transfer to other modes of transportation (e.g., rail, ship or bus) without further screening. Additionally, integrated trip tracking, with access by authorized third-party organizations,

provides custom services such as remote check-in and baggage transport and processing capabilities.

6.3.4 Secure Cargo/Mail

Cargo represents a critical vulnerability that was historically addressed with background investigations, inspections, and paper trails required of shippers, both known and unknown. The NextGen vision for cargo security moves beyond that to also include freight vulnerability assessments (through the IRM process), identifying the risk level of cargo, use of sterile cargo packing areas, cargo transit safety and integrity, and CBRNE screening for air cargo.

Secure Cargo/Mail is intended to prevent checked cargo/mail from endangering aircraft, aviation facilities, or people and to prevent the air cargo system from being used as a threat vector. These objectives are met through a combination of policy, procedures, information, and technology to accurately differentiate normal commerce from threats. Cargo/mail screening equipment and container sensors, with multi-sensor capabilities, are linked through secured NEO to the SSP Airport Security Operations Center and other analysis centers.

The security of cargo and mail begins at the point of initial packing (or when initial screening occurs prior to entry into the NextGen Security System) with the manufacturer, freight consolidator, air carrier, or licensed U.S. Customs broker. The SSP integrates all information related to the flight, cargo, and aircrew to provide additional information and ensure security during transit, enabled through NEO. The SSP includes the following concepts:

- Vetting for Secure Supply Chain Entity (SSCE)
- Vetting for Certified Supply Chain Entity (CSCE)
- Security screening
- Loading and storage security
- Surface transportation security/tracking
- Cradle-to-grave tracking/integrity

The air cargo supply chain potentially has many organizations and personnel involved in the transport of any given piece of cargo: a source or shipper, freight forwarders, indirect air carriers, and other commercial and government personnel. Because of the many prospective transfer points, cargo/mail security has to take into account the entire custody chain. A continuous risk and threat assessment must be conducted to identify risks to the supply chain, assess those risks, and apply measures, procedures, and policy to reduce those risks to an acceptable level. A secure supply chain encompasses the concept that cargo must be initially packed in a sterile area and conveyed through a secure chain of custody to the aircraft. If any deviance from this process occurs, all cargo intended for air transport, whether on passenger flights or all-cargo operations, must undergo CBRNE screening from either the SSP or a CSCE. After CBRNE screening, the integrity of the goods shipped must be maintained until the cargo exits the air transportation system. SSCE and CSCE are regularly inspected for compliance. All personnel with access to shipped goods must be properly credentialed, authenticated, and trained to ensure a secure

shipping environment. In addition, all cargo items are subject to random inspection and CBRNE screening to maintain necessary variability and verification of the supply chain.

6.3.5 Secure Airspace

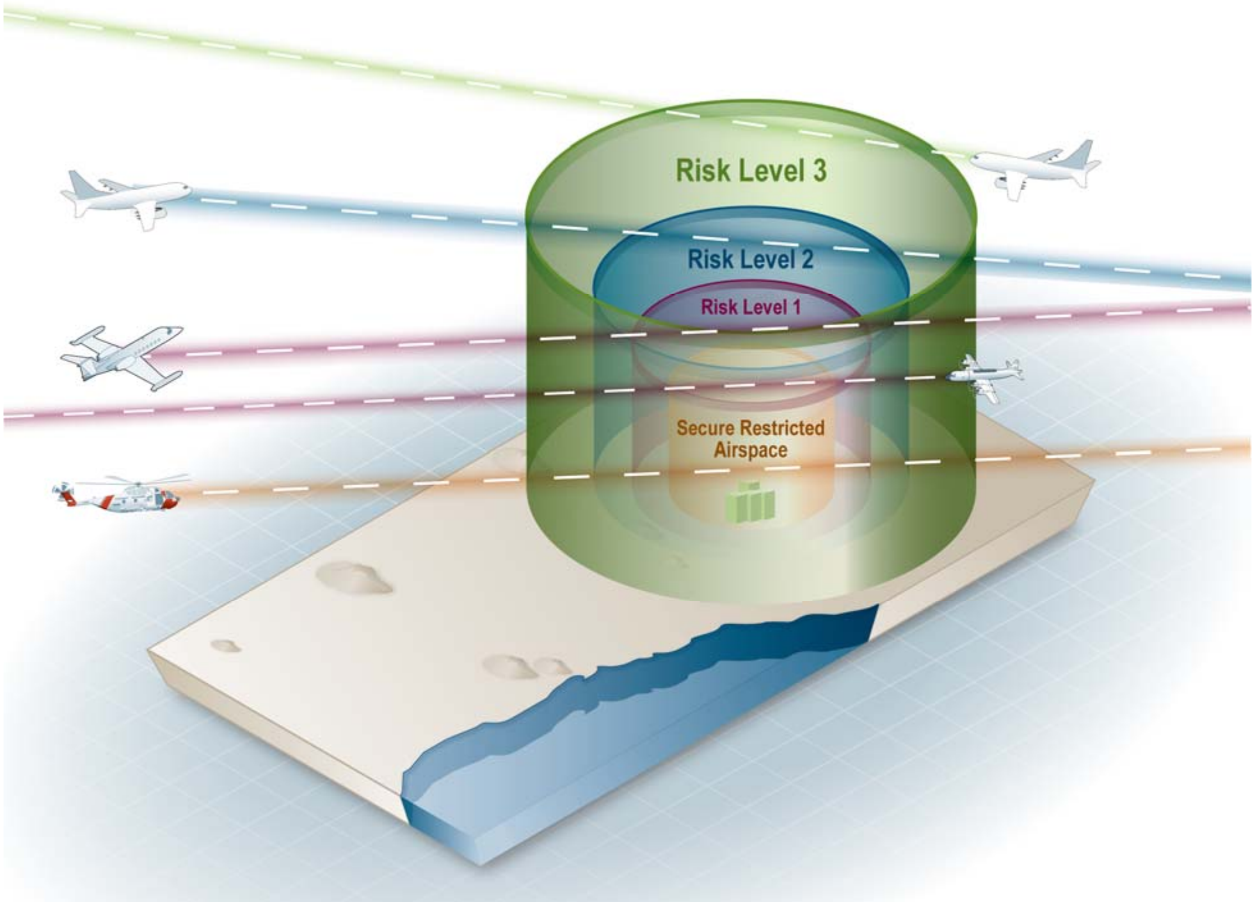
The major objective of Secure Airspace is to prevent or counter external attacks on aircraft and other airborne vehicles anywhere in the NAS and to prevent or counter use of an aircraft as a weapon to attack assets and people on the ground. To reduce the security risk within the air domain, NextGen Secure Airspace systems and procedures detect and prevent or mitigate:

- Anomalies in aircraft operation that indicate unauthorized use or attempted unauthorized use
- Aircraft not providing the appropriate cooperative data concerning identity and intentions
- External attacks on aircraft
- Aircraft that can pose a threat from operating in the NAS.

These risk management requirements include the following: (1) defining (almost always dynamically) the boundaries and access criteria of SRAs to protect people/assets, critical infrastructure and significant events, (2) clarifying the cooperative respective roles and responsibilities between the defense security provider, SSP, and air navigation service provider in the event of security incidents in flight or by airborne threat aircraft, and (3) determining the risk profiles of flights.

The NextGen SRAs include the current concept of SUA and temporary flight restrictions with additional considerations given to flight risk profile. Secure Airspace implements airspace access and flight procedures based on a verification process that dynamically adjusts for aircraft performance and security considerations. One objective is to permit increased NAS access by low-performance aircraft through most restricted zones because the reaction time to intercept is correspondingly greater than with high-performance aircraft. Secure Airspace also has Airspace Violation Detection, Alerting, and Monitoring capabilities. Refer to Chapter 2 for additional information. A depiction of secure airspace is provided in Figure 6-1.

Figure 6-1. Secure Airspace - Security Restricted Airspace



6.3.6 Secure Aircraft

The Secure Aircraft Service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods. The threats that require mitigation include, but may not be limited to, hijacking/unauthorized diversion; internal explosive destruction; external attack; onboard CBRNE or other attack of crew, passengers, or aircraft systems; aircraft use as a transport for CBRNE; or aircraft use as a weapon of mass destruction. The Secure Aircraft Service applies to both civilian passenger aircraft and civilian cargo aircraft. UAS aircraft (surveillance or cargo) are included as well for threats related to unauthorized diversion, internal explosive destruction, and use as a transport for CBRNE.

7 Environmental Management Framework

7.1 INTRODUCTION

Understanding and effectively addressing environmental challenges is a major component to Next Generation Air Transportation System (NextGen) success. Anticipated increased capacity will result in greater environmental impact and new challenges to address. Unless the environmental impacts in the areas of noise, emissions, water quality, and greenhouse gas emissions are managed and mitigated, there will be significant constraints to increasing National Airspace System (NAS) capacity.

For NextGen to be successful, airports will need to increase their efforts to address the environmental concerns of neighboring communities. Noise has been and will continue to be a primary area of concern; however, air quality, water quality, and other environmental demands are a growing challenge to significant capacity expansion without a detrimental impact to the environment. NextGen's environmental challenge is to manage aviation's environmental impacts in a manner that limits or reduces their "footprint" and enables the U.S. air transportation system to meet the nation's future transportation needs.

NextGen's solution to managing mission-critical environmental resources/impacts is through the development of an Environmental Management Framework (EMF) that is fully integrated into all NextGen operations. This framework ensures *environmental protection that allows sustained aviation growth*. The EMF is structured to address the management of environmental resources using five functional groups focused on policy, operations, technology, tools and science, and metrics. The EMF must account for interdependencies among many environmental issues so that in addressing some, others are not exacerbated. While at the same time, the EMF must maintain a balance between environmental goals and the need to advance aviation safety, national security, and economic well-being. The goals of the NextGen EMF include:

- Reduce significant community noise and air quality emissions impacts in absolute terms
- Limit or reduce the impact of aviation greenhouse gas emission on global climate, including the rate of fuel burn
- Improve energy efficiency of air traffic operations
- Support alternative fuels development
- Proactively address other environmental concerns

To help achieve NextGen goals, the NextGen EMF promotes the development of a national Environmental Management Systems (EMS) approach. EMS includes a management process to help users systematically identify, manage, monitor, and adapt to the environmental demands associated with the high volume and dynamic nature of the air transportation system. The

national EMS approach is intended to facilitate an effective and common process that is adopted by all applicable U.S. aviation organizations, and therefore provides a mechanism for integrating environmental protection objectives into the core business and operational decision making of NextGen. While EMF provides the overarching strategy needed to achieve environmentally sustainable aviation growth, EMS delivers a management process for achieving environmental protection in user actions.

This chapter describes the operational concept of the NextGen EMF, including the key transformed environmental operations (Section 7.3.1) that will be enabled in NextGen, and services and capabilities (Section 7.3.2) that need to be implemented to enable these transformations.

As shown below, the NextGen Provide Improved Environmental Performance capability will use the EMS to provide enhanced environmental responsiveness in the areas of aviation airspace operations, airport planning and operations, and transformed aircraft design and technologies. These capabilities enable the fundamental operations of NextGen and transform the national airspace operation. The remaining sections in this chapter describe the vision of NextGen environmental framework.

Provide Improved Environmental Performance: Improved Environmental Performance ensures environmental management considerations, including flexibility in identifying, preventing, and proactively addressing environmental impacts, are fully integrated throughout the air transportation system decision-making process, through increased collaboration and improved tools, technologies, operational policies, procedures, and practices that are consistent and compatible with national and international regulations.

7.2 PROVIDE IMPROVED ENVIRONMENTAL PERFORMANCE OF NEXTGEN SYSTEM COMPONENTS

7.2.1 Environmental Operations

The NextGen EMF is the overarching environmental architecture (including systems, business processes, and infrastructure) that supports NextGen. Changes in the air transportation system can result from increased traffic volume and are compounded by greater stakeholder and community awareness of environmental issues and increasing community expectations for environmental impact reductions. The most commonly impacted aviation system components are described in Sections 7.3.1.1 through 7.3.1.4.

7.2.1.1 Aviation System EMSs

The NextGen EMF does not treat the aviation system as a single unit, but as a community of organizations with a diverse range of requirements and drivers. The framework establishes systematic but flexible approaches that enable individual EMS programs to respond to the aviation system's dynamic capacity demands. These approaches are supported by enhanced information flow and better connections between individual component organizations.

The NextGen EMF aims to provide individual air transportation component organizations (e.g., airports, agencies, air carriers, and manufacturers) with a flexible system to identify and manage the environmental resources that are necessary to meet their individual long-term capacity demands. This includes integrating sound EMS principles into all aviation system component organizations (e.g., airports, air carriers, air navigation service providers [ANSP], and Federal Aviation Administration [FAA]) and ensuring that these EMS approaches, or models, include all environmental issues but focus specifically on capacity-related environmental issues. NextGen EMS models establish standardized, systematic approaches for managing the environmental aspects of operations in support of the organization's overarching mission. The use of NextGen-focused EMS models ensures that all aviation system component organizations contain processes that help them align with critical NextGen goals.

Implementing EMS models with a focus on NextGen activities will provide mechanisms for identifying and managing issues critical to sustainable growth, transferring information, standardizing operations based on best practices, and encouraging environmental stewardship. The implementation also provides a vehicle for NextGen-level objectives to be incorporated by individual organizations as part of their EMSs, thereby aligning them with NextGen goals. Individual organizations (e.g., airports, air carriers, and FAA) connect through an information management system. As discussed in Section 7.3.2, this system enables environmental information management, including tracking environmental metrics, storing best practices (e.g., on construction, maintenance, and operational procedures), and communicating NextGen environmental objectives, policies, incentives, and regulations.

What are Environmental Management Systems?

EMS is an organizational business process that consists of four phases. In the "planning" phase of an EMS, the organization identifies environmental issues with the potential to constrain future capacity. These are the focus of tactical, measurable objectives for which improvement initiatives can be undertaken during the "implementation" phase. During the "assessment" phase, the effectiveness of these initiatives is monitored and key performance metrics are tracked. Monitoring data is then used to support planning at the organization itself in the "review and adaptation" phase. In the NextGen EMS, monitoring data is also reported at an enterprise level to support NextGen-wide planning.

7.2.1.2 Airspace Operations

The NextGen plan seeks to create a dynamic and flexible airspace capable of supporting 2025 demand in an environmentally sustainable manner. An agile air traffic system based on advanced cockpit avionics, satellite navigation, and dynamic airspace has enhanced ability and flexibility to reduce emissions by maximizing routings for fuel efficiency. Environmental performance of the system is embedded in the overall performance of the air traffic system and supported by EMS goals, including the availability of up-to-date critical system information.

Consistent with EMS principles, a holistic but flexible approach is used to manage key environmental issues as they pertain to specific geographic regions and to the system as a whole. This approach accounts for variations at an individual component level (e.g., airports or air carriers); EMS models implemented by individual components account for specific needs while also contributing to system-level requirements.

Environmental impacts and potential constraints of terminal airspace currently are better understood than those associated with en route airspace, but there is significant uncertainty associated with 2025 projections for both. Therefore, the primary capability of the EMF is its ability to adapt to the complex nature of the air traffic system. For example, new technology in concert with airspace redesign, enables optimized route selection during landing and takeoff procedures that are based on minimizing the impact of noise and emissions, minimizing costs and fuel burn, and maximizing route efficiency and safety. The establishment of environmentally friendly operational procedures (e.g., operations program directives) for all traffic conditions is one example.

In terminal airspace, single-purpose procedures are replaced by more sophisticated procedures that maximize benefits based on integrated assessment and management of multiple factors, including noise, emissions, fuel burn, land use, operational efficiency, and cost. Procedures are dynamic and adapt to changing needs rather than remaining static. There are additional procedures available using advanced technologies from which to select the best operational and environmental benefits.

In the case of the en route environmental impacts, ongoing discussions and analyses have resolved major questions, and outcomes are integrated into the EMF. Specific focus is placed on understanding and identifying the direct attributable role of aircraft emissions in climate change through targeted research with national and international partners.

7.2.1.3 Transformed Airport Planning and Operations

The greatest interaction between the NAS, communities, and environmental resources occurs at airports. By 2025, significant aircraft noise is expected to be confined within the airport boundary and over small areas of adjacent compatible land. During this time frame, airports will become emissions-friendly with ongoing transition to low- or no-emissions stationary facilities and ground service equipment (GSE). Airport and community planning complement and support each other, and airports are valued community assets as air transportation gateways and economic engines. Through the integration of EMSs, environmental planning and mitigation is continuous and includes activities to meet long-term goals for sustainable growth in airport capacity. These activities are supported by improved information management that, for example, transfers and stores information on environmentally preferable airport practices. In addition, an advanced capability to integrate and balance noise, emissions, fuel burn, land use, energy efficiency, and the costs and effects of alternative measures will allow the selection of optimum operational modes, mitigation strategies, and surface planning procedures.

The implementation of a NextGen-focused EMS will provide a flexible systematic approach to identify and manage environmental aspects of operations to meet capacity needs and environmental goals. The EMS approach is adaptable to the airport's characteristics, such as its

size (large or small), its ownership (public or private), and its geography. Such a model allows airports to assess and improve environmental performance on an ongoing basis that is linked to airport development, and it facilitates both capacity growth and environmental protection. The noise, air quality, and water quality concerns identified by airports and communities as critical to sustainable growth are fully integrated into management plans that have the ability for mid-course adjustment based on continuous feedback . Therefore, airports are able to assess their specific environmental requirements for sustainable growth and develop or select approaches (based on industry best practices) to address specific operational, geographic, and local community impacts that fit within that national framework.

Local environmental monitoring allows the effects of management strategies to be assessed and best practices or lessons learned to be available in real time. Monitoring enables regional and national trend analysis and supports decision making and planning. Improved environmental information availability and subsequent information sharing ensures that proven practices are widely used and successes quickly proliferated.

7.2.1.4 Aircraft Design and Technology

Environmental considerations are a critical component of aircraft design and operations. These design and operational improvements also aim to reduce costs to aircraft operators, airports, and the ANSP. As regulation and environmental impact increasingly constrain capacity, public/private sector partnerships deliver more robust research and development that enables technological breakthroughs to reduce significant impacts. Scalable models and analytical capabilities that integrate noise, emissions, fuel burn, costs, and other factors enable development of the optimized aircraft performance characteristics, based on informed decisions of any necessary tradeoffs (e.g., between noise and emissions).

The development of alternative fuels for aircraft is driven by costs, energy supply, security concerns, and environmental factors. Alternative fuels will be available and in service by 2025.

Use of environmentally sensitive technology will facilitate a prompt and efficient development process where innovation, such as environmentally friendly airframe and engine design, is encouraged. Design, product development, testing, and certification steps are well established, with changes in policy enabling a more direct flow from concept through implementation. This, combined with increased demand from aircraft operators, provides for a strong market for environmentally sensitive aviation technology.

7.2.2 Environmental Management Framework Policies and Capabilities

The NextGen EMF is a single, fully integrated, interconnected system. NextGen uses this framework to manage and mitigate environmental impacts that constraint capacity in the NAS. An integrated NextGen EMF, consistent with this Concept of Operations, is based on researching, designing, and implementing a broad set of enabling services and capabilities (i.e., systems and infrastructure). These services and capabilities are described in subsections 7.3.2.1 through 7.3.2.5. Each plays an important role in supporting the transformational operations of NextGen. Figure 7-1 depicts the EMF Process.

7.2.2.1 Policy

NextGen Environmental Policy. Although many air transportation system component organizations have robust environmental programs, the focus of these multiple programs varies. Development of a unified NextGen environmental policy supported by a wide array of air transportation system stakeholders (e.g., airports, aircraft operators, agencies, and communities) will assist component organizations with aligning their environmental systems with NextGen goals and objectives. The establishment of long-term measurable targets that address environmental issues critical to NextGen (e.g., noise, emissions, fuel, climate effects, and water quality) is central to this policy. While this policy provides an overarching framework for NextGen, it also allows sufficient flexibility to ensure that organizations can design their programs to meet their unique challenges. Performance metrics provide a yardstick for monitoring and assessing progress toward meeting environmental targets. Metrics will be appropriate for use by the various air transportation system component organizations. These will be reported via a net-centric environmental information management system for the purposes of analysis, continuous improvement, and public dissemination.

Figure 7-1. Environmental Management Framework

Standardized EMS Model. There are a wide variety of approaches and methodologies for the application of EMSs. This flexibility is critical for EMSs to be applied to a diverse range of organization types; however, to meet future capacity challenges, NextGen EMSs will need to

include mechanisms for incorporating overarching environmental objectives (e.g., reduction of community noise), reporting with standardized metrics, and linking to a NextGen environmental information management system. The NextGen EMS model will be developed using existing best practices based on the globally recognized International Organization for Standardization (ISO) 14001 standards and will be sufficiently flexible to support the diverse needs of aviation system component organizations.

Incentives System. Although the NextGen EMF is expected to eventually bring about cost savings to the system as a whole by increasing efficiency, incentives will likely be necessary to increase implementation and encourage environmental improvements at a more rapid pace than the market would normally provide. The consideration of incentives would be tied to specific NextGen environmental program initiatives or goals.

Information Management System. A robust information management system is critical for transferring environmental information throughout the NextGen system. This system, for example, couples shared available information to provide real-time information to aircraft operators and the ANSP on dynamically forecasted areas of noise sensitivity, areas susceptible to dispersion of pollution, and volumes of airspace that are sensitive to emissions, so that these factors can be included in planning routes, approaches, and departures. This enables communication between different NextGen organizations so airports can share best practices or receive updates on new policy, regulation, or other initiatives with the NextGen system. Organizations are also able to directly input environmental metrics data, such as emissions and noise monitoring data, from monitoring equipment into the system. Subsequent data analyses enable better decision making and policy development, allowing for the adjustment of environmental objectives. They also facilitate the development of effective incentives and communication of all of these actions seamlessly across the NextGen system in an efficient manner. Therefore, this single enterprise-wide system supports all the environmental information management needs of the NextGen.

7.2.2.2 Operations Initiative

Integrated Environmental Planning. More flexible planning enable airports to make midcourse corrections to planned initiatives, thus shortening the planning horizon. Planning includes greater involvement of stakeholder groups and local communities. As part of the EMS, airports conduct standardized environmental evaluations to identify environmental resources that are adversely impacted and/or have the potential to constrain future airport capacity. This information supports long-term planning efforts and helps direct airport improvement initiatives to mitigate potential future resource constraints. Standardized environmental evaluations are reported via the information management system so that it is possible to identify the specific, local environmental issues that must be addressed for NextGen to be enabled. This allows organizations to review regional and national trends and support planning and decision making within NextGen.

Airport Approaches. A range of environmentally sensitive operational procedures are developed to assist airports and aircraft operators with minimizing environmental impacts. Currently, most aircraft use the standard approach route at an airport, though large numbers of noise abatement procedures are used; however, aircraft that use quiet technology will no longer produce significant noise impacts and therefore will be able to use a wide range of approaches.

These procedures, developed based on improved tools and information (e.g., real-time weather information), increase airport efficiency and ensure the maximum number of aircraft operations can be accommodated within environmental limits (e.g., state implementation plan air quality requirements, land use compatibility guidance with aircraft noise exposure, or water quality regulations), without impacting capacity.

Environmental Routes Consideration. This initiative introduces environmental considerations into the route planning decision-making process, including identifying and considering cumulative effects in routing decisions and providing preference to quieter and less-polluting aircraft. In addition, advanced navigation systems enable greater routing flexibility without impacting capacity, while also enabling en route adjustments according to on-the-ground conditions (e.g., designated quiet times or air quality emergency days). For example, aircraft that have low noise and emissions have access to a wider selection of routes than those that do not have comparable technology. Enhanced real-time weather information allows better prediction of noise and emissions impacts.

Ground Procedures. The implementation of EMSs encourages the use of a range of environmentally sensitive and cost-effective standardized procedures for ground activities. These include converting airport GSE to alternative and low-emission fuels (e.g., use of fixed underground services), reducing the time spent on the ground by aircraft, reducing the use of auxiliary power units, using environmentally sensitive deicing chemicals, and employing a wide range of other procedures. These standardized airport ground procedures are focused on enhancing surface operations, reducing delays, and minimizing environmental impacts. In particular, through the implementation of EMS, organizations use these activities in a focused manner, specifically targeting identified environmental impacts.

Analytical Tools. Understanding the relationship and interdependencies between various environmental impact categories is critical. For example, if an action is taken to reduce emissions, will this affect another impact category, such as noise? A suite of transparent, integrated aviation noise and emissions models is developed to help planners understand the environmental impacts of their actions holistically. The suite of models includes:

- The Environmental Design Space, a capability to provide integrated analysis of noise and emissions at the aircraft level
- The Aviation Environmental Design Tool, which provides integrated capability to generate interrelationships between noise and emissions and among emissions at the local and global levels
- The Aviation Environmental Portfolio Management Tool, which provides the common, transparent cost/benefit methodology needed to optimize choice among standards, market-based options, policies, and operational procedures to gain the largest environmental benefit while understanding cost

This suite of models allows government agencies and airport operators to understand how proposed actions and policy decisions affect noise and emissions. The models help industry

understand how operational decisions influence proposed projects related to aviation noise and emissions.

The tools allow optimized environmental benefits of proposed actions and investments, improved data and analyses on airport/airspace capacity projects, and increased capability to address noise and emissions interdependencies in the resolution of community concerns, health and welfare impacts, and better targeting of solutions to problems. Ultimately, they will facilitate more effective portfolio management and support the EMS process.

7.2.2.3 Technology

Clean and Quiet Technologies. In the near term, new technologies to improve air traffic management enable new, quieter, and cleaner operations. In the mid-term, technologies from NASA's Quiet Aircraft Technology and Ultra-Efficient Engine Technology programs will be matured for private-sector implementation. In addition, the Research Consortium for Lower Energy, Emissions, and Noise Technology (CLEEN) is a partnership developed to make the aviation technology advances needed for quieter, cleaner, and more energy efficient NextGen. In the long term, new engines and aircraft will feature enhanced engine cycles, components to enable quieter operations, more efficient aircraft aerodynamics, and reduced weight. These technology advancements enable significant reductions in noise and emissions.

Technology Development Processes. Aircraft design, navigational capabilities, and technology play a central role in NextGen's ability to increase capacity. The development of environmentally sensitive technology is encouraged by an efficient, expeditious research and development program. A critical aspect will be the development of an innovative and sustainable source of funding and the formation of public/private partnerships to facilitate the movement of technology from the conceptual phase through to its operational use in NextGen. CLEEN is an example of the type of partnership needed to advance technology.

7.2.2.4 Science/Metrics

Environmental Metrics. Environmental performance indicators (e.g., noise and emissions), combined with other system information (e.g., forecasted traffic flows, market data, fleet size, technology implementation, and operational procedures), provide the needed information to quantify the individual environmental impacts (noise impacts, local air quality, and global climate change). Based on information from the results of such scientific assessments, environmental metrics are defined to put environmental impacts on a common scale and assign relative priority to reach a quantified goal. The metrics are used to derive analytical tools to study interdependencies and perform cost/benefit analyses. These tools in turn drive policy, regulations, incentive programs, national objectives, operational procedures, and technology design goals. The development of new metrics to assess the impact of aviation activities on environmental and health and welfare enables a robust NextGen EMS framework. Next-generation metrics, based on improved scientific knowledge and computations of interdependent relationships and related benefit/costs, provide an enhanced platform for environmental decisions and mitigation. Metrics include new operating paradigms, such as very light jets and supersonic aircraft.

7.2.3 Environmental Management Framework Support

The EMF focuses on improving linkages between various components of the air transportation system (e.g., airports, aircraft operators, federal agencies, and manufacturers) and establishing a systematic but flexible framework to meet NextGen environmental protection needs for sustainable growth. Where possible, this aims to enable decision making and planning at the implementation level with support from several mission support functions. These functions (e.g., environmental, market, social trends, best practices, lessons learned, feedback, incentives, monitoring) are accessible to provide more robust information to all components of NextGen through an information management and communication system. In addition, cross-functional groups that include representatives from all stakeholder entities are assembled to review trends, policy, monitoring, and goals at a national level. These groups provide a forum for discussing research, funding, policy, regulation, tools, and other issues linking the aviation system as a whole.

8 Safety of Air Transportation Services

8.1 INTRODUCTION

The U.S. air transportation system is the safest in the world and has been for a long time. Achieving the Next Generation Air Transportation System (NextGen) safety objectives of improving the level of safety of the U.S. air transportation system. Increasing the safety of worldwide air transportation requires the future air transportation system to control known risks, identify emerging risks before they become accidents, and integrate safety into system evolution.

Creating the potential for significant growth in system capacity demanded by NextGen will introduce increased complexity in the air transportation system, and commensurate improvements in safety performance will be necessary. To achieve these improvements, there must be a fundamental change in the way safety is approached. Today, safety improvements are largely focused on addressing prior accidents. Under NextGen, Safety Management Services will evolve from today's post-accident interventionism to predictive evaluation and management of hazards and their potential safety risks. The Joint Planning Development Office (JPDO) Safety Working Group has created a NextGen safety management framework that is based on a National Aviation Safety Strategic Plan, which has been coordinated across industry and the NextGen government partners. The plan established the following three NextGen safety goals:

- **Safer Practices**. Safety is assured by applying consistent safety management approaches; comprehensive safety information sharing, monitoring, and analysis; and developing NextGen to have inherent safety.
- **Safer Systems**. Aviation system technologies are aimed at managing hazards, eliminating recurring accidents, and mitigating accident and incident consequences.
- **Safer Worldwide**. System technologies, standards, regulations, and procedures are harmonized domestically and internationally to create an equivalent and improved level of safety across air transportation system boundaries.

This chapter focuses on the transformations and expectations for safety in the 2025 time frame. The safety goals for NextGen are intended to permit increases in capacity and efficiency by ensuring that the system's safety is maintained. As NextGen concepts are designed and developed, they will be expected to contribute to the NextGen safety goals of Safer Practices, Safer Systems, and Safer Worldwide. As stated earlier, NextGen concept implementation must mitigate known risks. It also must not introduce significant sources of new risk. Transforming the air transportation system will include technological changes and human and institutional adjustments. Safety risks associated with changing roles and responsibilities for individuals and organizations may prove quite challenging to implement safely.

As shown below, the NextGen Provide Improved Safety Operations capability describes a safer, more efficient, higher capacity air transportation system. Key transformations incorporated and

outlined by this capability are further highlighted and described in this chapter, specifically the NextGen transformations that support the safety management functions addressed in Section 8.2.

Provide Improved Safety Operations: Improved safety operations ensure safety considerations are fully integrated throughout the air transportation system through increased collaboration and information sharing, improved automation (e.g. decision support systems), prognostic safety risk analysis, and enhanced safety promotion and assurance techniques that are consistent and compatible with national and international regulations, standards, and procedures.

8.2 SAFETY MANAGEMENT ENTERPRISE OPERATIONS

The JPDO, along with its member agencies and industry partners, will ensure the safety of NextGen by establishing and maintaining a National Aviation Safety Strategic Plan for the air transportation system. Key aspects of this plan include facilitating and stimulating the continuous improvement of the safety culture among NextGen stakeholders; consistently, systematically, and proactively applying and improving safety risk management practices, including increasing the sharing of safety-critical data; and enhancing safety assurance. The JPDO and its stakeholders will jointly define an optimal safety management system (SMS) that leverages government and industry experience to quickly identify and address non-normal, tactical, and strategic increased risk operations.

8.2.1 National Aviation Safety Strategic Plan

A clear and cohesive National Aviation Safety Strategic Plan promotes continuous improvement in safety practices and systems safety, domestically and internationally, across air transportation system boundaries. This plan serves as the guiding principle for all government and industry participants in NextGen. It sets objectives and identifies strategies within each goal area. Safer Practices seek to provide consistent safety management approaches that are implemented throughout government and industry, to provide enhanced monitoring and safety analysis of the air transportation system, and to provide enhanced methods to ensure that safety is an inherent characteristic of NextGen. Safer Systems seek to provide risk-reducing systems interfaces, and to provide safety enhancements for airborne and ground-based systems. Safer Worldwide encourages development and implementation of safer practices and safer systems worldwide, and seeks to establish equivalent levels of safety across air transportation system boundaries.

8.2.2 Safety Improvement Culture

A positive safety culture will focus government and industry on “doing the right thing” by empowering individuals across functional lines to act upon reliable data according to clear expectations of measurement and behavior. The safety culture of an organization is the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety programs. A positive safety culture is pervasive throughout all government and industry aviation stakeholders, thus facilitating a more proactive use of Safety Risk Management (SRM) principles

and practices. These characteristics include, but are not limited to, management accountability, non-reprisal reporting, consistent use of SRM best practices, and sharing safety data and lessons learned.

8.2.3 Safety Risk Management

SRM is a construct that takes into account the frequency of an undesired outcome along with the possible consequences, permitting a rationale for appropriate prioritization of remedial action. It is a structured approach for identifying potential breakdowns in the system's operation, understanding the impact they may have on safety, identifying mitigation strategies, and evaluating and monitoring the strategies effectiveness. NextGen uses advanced data analysis, risk modeling, and simulations techniques, where applicable, for a systematic and comprehensive understanding of system and operational risk. These techniques are used to identify and understand the roles of precursors in past and potential accidents, and to evaluate the effectiveness of risk mitigation strategies, thus allowing accident precursors to be identified and proactively managed. Understanding the accident precursors and the effectiveness of risk mitigation strategies helps "… ensure safety requirements are established at the front end of every aviation process to prevent accidents before they happen."[12] Prognostic risk assessments based on data analysis and risk modeling techniques are used where feasible to quantify safety risk levels of system changes prior to implementation. Appreciating the interdependent and hierarchical risks of various NextGen operational improvements ensures optimal resource allocation for safety research and implementation.

8.2.4 Safety Information Integration

The integration and sharing of high-quality, relevant, and timely aviation safety information is critical to the operational success of the Safety Management Enterprise. The Aviation Safety Information Analysis and Sharing (ASIAS) environment is a combination of processes, governance, technologies, information protection policies and standards, and architectures used to connect Safety Management Enterprise resources, including information, organizations, services, and personnel.

In 2025, the ASIAS environment will support multiple levels of stakeholders within the Safety Management Enterprise, including government and private-sector decision makers with the responsibility of maintaining the aviation record as the safest mode of transportation. To do this, ASIAS provides easy access to a suite of tools used to extract relevant knowledge from large amounts of disparate safety information.

To facilitate the trusted exchange of aviation safety information, ASIAS leverages net-centric features by implementing need-to-know, role-based access capabilities. ASIAS plays a critical role in establishing and maintaining information protections. Further, ASIAS implements and continuously improves an Electronic Directory Service, a one-stop resource for stakeholders to discover relevant aviation safety information assets across multiple domains. Lastly, ASIAS establishes and continuously refines interoperability techniques by joining disparate data sources to uncover system-level hazards that were once undiscoverable.

[12] NGATS Integrated Plan, 2004.

8.2.5 Enhanced Safety Assurance

Safety Assurance is the independent oversight function that tests, evaluates, and certifies, as necessary, products and processes to ensure safety for the public and the stakeholders. The regulatory authority continuously measures and assesses the effectiveness of stakeholder SMSs through joint audits and trend analysis. Performance-based standards are continuously reviewed and revised as experience dictates. The responsibility for safety assurance is distributed among and between the regulators and the providers. As a result of this delegation, the regulatory authority is better equipped to focus resources on the most safety-critical systems and operations. To support national-level proactive hazard identification, risk assessments, and the Safety Assurance function, the "incompatible databases scattered throughout government and industry"[13] are transformed into a coordinated and interlinked data source using the network-enabled infrastructure. The safety-critical events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information.

8.3 SAFETY MANAGEMENT ENTERPRISE SERVICES AND CAPABILITIES

National-level SMSs are provided to facilitate safety management and cooperation across aviation stakeholder organizations. These services provide coordination of safety activities such as research and risk mitigation strategies, injection of critical and timely safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation. The safety services may be provided to varying degrees by local or federal government agencies, or by industry associations, technical societies, or other nongovernmental organizations. They may be either permanent or temporary bodies. These services have been grouped into categories further described in 8.3.1 through 8.3.5 below. This does not diminish the responsibility for improving and managing safety that is the foundation for each stakeholder organization's safety culture.

8.3.1 Aviation Safety Strategic Plan Service

The Safety Strategic Plan Service provides a coordinated and maintained National Aviation Safety Strategic Plan that establishes NextGen safety goals, and identifies objectives and strategies for implementation by government and industry in support of those goals.

8.3.2 Safety Promotion Service

The Safety Promotion Service provides:

- A Safety Culture Improvement Plan, which includes examples of strategies and tools that can be used by the stakeholders
- Implementation guidelines for safety culture improvement

[13] NGATS Integrated Plan, 2004.

- Capabilities for additional research into the relationship between safety climate scores and mishap rates
- Development and distribution of material that facilitates awareness of the importance of organizational culture in fostering safety

8.3.3 Safety Risk Management Service

The Safety Risk Management Service provides:

- Safety data management capability, including data sharing and protection, and formatting requirements to facilitate data analysis and reporting
- Integrated NextGen-wide risk assessment capability via data analysis, models, and simulations development, maintenance, and applications designed as an aid to understanding the relative risks across NextGen and also the effectiveness of mitigation strategies
- Continued understanding of safety culture impacts on NextGen safety
- Assessments of the impact on safety (including on safety culture) of proposed new regulations

8.3.4 Safety Information Integration Service

The Safety Information Integration Service provides:

- A one-stop shop for aviation safety information required to support the Safety Management Service
- Large amounts of safety information from multiple domains under one virtual roof
- Processes for acquiring access to data from multiple, disparate information sources
- Authorized end users with easy and timely access to relevant aviation safety information
- Role-based, need-to-know authorization features
- Coordination and maintenance of aviation safety information protection policies and procedures
- Adaptation to meet the ever-changing safety information requirements of the Safety Management Enterprise operations

8.3.5 Safety Assurance Service

The Safety Assurance Service provides:

- Certification
  - SMS certification

  - System and operation certification
- Training
- Independent evaluations (using SRM services) of systems, operations, and safety culture
- Accident investigation services
- Other regulatory and oversight services
- Integration of safety management into infrastructure planning and management, and into intermodal operations
- Regulatory and policy enforcement service

8.4 INTEGRATION OF SMS INTO NEXTGEN SERVICES

All modifications to existing systems, procedures, equipment, and policies, and all transformations undertaken by the services to achieve NextGen, undergo the safety risk analysis and management process. Each of the services identifies the requirements to meet safety performance requirements through integrated safety assessments and implements SMS to accomplish the goals. The NextGen-integrated SMS specifies a collaborative and integrated safety hazard/mitigation strategy. Results from safety assessments are factored into the operational data requirements for each of the services. SMS data required for identification and tracking of hazards and trend analysis is centrally managed and accessible to users. SMS best practices and lessons learned are coordinated across the services.

Appendix A: Acronyms

Term	Definition
3D	Three-Dimensional
4DT	Four-Dimensional Trajectory
ACAS	Airborne Collision Avoidance System
AEDT	Aviation Environmental Design Tool
AIS	Aeronautical Information Services
ANSP	Air Navigation Service Provider
ANT	Automated NextGen Tower
AOC	Airport Operations Center
APMT	Aviation Portfolio Management Tool (Environmental)
APU	Auxiliary Power Unit
AR	Aerial Refueling
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control
ATM	Air Traffic Management
BLOS	Beyond Line-of-Sight
BRAC	Base Realignment and Closure
C-ATM	Collaborative Air Traffic Management
CBP	Customs and Border Protection
CBRNE	Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive
CDM	Collaborative Decision-Making
CFR	Code of Federal Regulations

Term	Definition
CIP	Capital Improvement Program
CLEEN	Consortium for Lower Energy, Emissions, and Noise Technology
CM	Capacity Management
CNS	Communications, Navigation, and Surveillance
COI	Communities of Interest
ConOps	Concept of Operations
CSCE	Certified Supply Chain Entity
CSPA	Closely Spaced Parallel Approach
CST	Commercial Space Transportation
CTA	Controlled Time of Arrival
CUTE	Common-Use Terminal Equipment
DHS	Department of Homeland Security
DOC	Department of Commerce
DoD	Department of Defense
DOJ	Department of Justice
DOT	Department of Transportation
DSP	Defense Service Provider
DSS	Decision Support System
DST	Decision Support Tool
DUAT	Direct User Access Terminal
EDS	Environmental Design Space
EMAS	Engineered Material Arresting System

Term	Definition
EMP	Electromagnetic Pulse
EMS	Environmental Management System
EVFR	Electronic Visual Flight Rules
EVO	Equivalent Visual Operations
FAA	Federal Aviation Administration
FCAPS	Fault, Configuration, Accounting, Performance, Security
FCM	Flow Contingency Management
FDMS	Flight Data Management Services
FIDS	Flight Informational Display Systems
FIR	Flight Information Region
FL	Flight Level
FOC	Flight Operations Center
GA	General Aviation
GIS	Geospatial Information Services
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSE	Ground Support Equipment
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions

Term	Definition
IRM	Integrated Risk Management
ISO	International Standards Organization
JPDO	Joint Planning and Development Office
LAAS	Local Area Augmentation System
MANPADS	Man-Portable Air Defense System
MOA	Memoranda of Agreement
MPO	Metropolitan Planning Organization
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NAVAID	Navigational Aid
NDOT	NextGen Decision Oriented Tool
NEI	Network Enabled Infrastructure
NEO	Network Enabled Operations
NextGen	Next Generation Air Transportation System
NGATS	Next Generation Air Transportation System (old)
NIMS	National Incident Management System
NNEW	NextGen Network Enabled Weather
NOTAM	Notice to Airmen
NPIAS	National Plan of Integrated Airport Systems
OPD	Optimized Profile Decent
OSTP	Office of Science and Technology Policy
PIREP	Pilot Report (Weather)

Term	Definition
PIRG	Planning and Implementation Regional Group
POFZ	Precision Obstacle–Free Zone
PNT	Positioning, Navigation, and Timing
PWD	Person with Disability
QAT	Quiet Aircraft Technology
QoS	Quality of Service
R&D	Research and Development
RCP	Required Communications Performance
RFID	Radio Frequency Identification
RNAV	Area Navigation
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
RTSS	Remote Terminal Security Screening
SAA	Special Activity Airspace
SIDA	Security Identification Display Area
SM	Separation Management
SMS	Safety Management System
SNT	Staffed NextGen Tower
SOA	Services Oriented Architecture
SRA	Security Restricted Airspace
SRM	Safety Risk Management
SSA	Shared Situational Awareness

Term	Definition
SSCE	Secure Supply Chain Entity
SSP	Security Service Provider
SUA	Special Use Airspace
SWIM	System-wide Information Management
TBO	Trajectory-Based Operations
TCAS	Traffic Alert and Collision Avoidance System
TERP	Terminal Instrument Procedure
TFM	Traffic Flow Management
TFR	Temporary Flight Restriction
TM	Trajectory Management
TMI	Traffic Management Initiative
UAS	Unmanned Aircraft System
UEET	Ultra-Efficient Engine Technology
UTC	Coordinated Universal Time
V/STOL	Vertical/Short Takeoff and Landing
VFR	Visual Flight Rule
VLJ	Very Light Jet
VMC	Visual Meteorological Condition
WAAS	Wide Area Augmentation System
WMD	Weapon of Mass Destruction
Wx	Weather

Appendix B: Glossary

Term	Definition
Aeronautical Information Service (AIS)	The near-real-time transmission of accurate aeronautical information, including updates on airspace restrictions; performance requirements for airspace access and operations; system outages; airport status information; static information, such as approach plates; and certain fixed airspace definitional data, such as fixed special activity airspace and airport information.
Air Carrier	Operational users of NextGen that includes commercial passenger or cargo airlines, military air commands, business aviation, and private air vehicle operators.
Air Domain	The global airspace, including domestic, international, and foreign airspace, as well as all manned and unmanned aircraft operating in and people and cargo present in that airspace, and all aviation-related infrastructures.
Air Navigation Service Provider (ANSP)	Used generically, ANSP refers to the organization, personnel, and automation that provide separation assurance, traffic management, infrastructure management, aviation information, navigation, landing, airspace management, or aviation assistance services for airspace users.
Air Traffic Management (ATM)	The dynamic, integrated management of air traffic and airspace—safely, economically, and efficiently—through the provision of facilities and seamless services in collaboration with all parties.
Airborne Self-Separation	All aircraft within the airspace or airport movement area maintaining separation from all other aircraft within the airspace or airport movement area according to defined rules and separation criteria. The ANSP is not responsible for separation between aircraft. When authorized by the ANSP, equipped aircraft in this airspace maintain separation from all other aircraft, including those managed by the ANSP.
Airborne Separation	Refers to separation delegated to an individual aircraft to maintain separation from a designated aircraft, either in flight or on the airport movement area, such as for a crossing or passing maneuver. Separation of this aircraft from all other aircraft, including all aircraft to which separation has not been delegated, remains the responsibility of the ANSP. Pairwise separation and closely spaced parallel approaches are also in this category.
Airborne Separation Assurance	A capability of the aircraft to maintain awareness of and separation from other aircraft, airspace, terrain, or obstacles. There are four different levels of airborne separation assurance (based on the RTCA definition)—airborne traffic situational awareness, airborne spacing, airborne separation, and airborne self-separation.
Airborne Spacing	The capability of one aircraft to achieve and maintain a defined distance in space or time from another aircraft. Separation responsibility remains with the ANSP.
Airborne Traffic Situational Awareness	Flight crew knowledge of nearby traffic depicted on a cockpit traffic display without any change of separation tasks or responsibility.

Term	Definition
Aircraft	Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface. An aircraft can include a fixed-wing structure, rotorcraft, lighter-than-air vehicle, or a vehicle capable of leaving the atmosphere for space flight.
Airport	A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft.
Airspace Classification	Airspace with a common air traffic management interest and use, based on similar characteristics of traffic density, complexity, air navigation system infrastructure requirements, aircraft capabilities, or other specified considerations wherein a common detailed plan will foster the implementation of interoperable CNS/ATM systems.
Airspace Design	The process of designing routes, fixes, sectors, and other structural/operational elements of the National Airspace System (NAS) while ensuring safety, security, and efficiency.
Air Navigation Service Provider (ANSP)	The organization, personnel, and automation that provide separation assurance, traffic management, infrastructure management, meteorological & aeronautical information, navigation, surveillance services, clearances, airspace management, and aviation assistance services for airspace users.
Air Navigation Service Provider (ANSP) Flow Airspace	High-density, moderate complexity airspace where the flight operator executes a 4DT agreement. Trajectory Management (TM) ensures the overall flows are well behaved so that potential conflicts are kept to a minimum. Separation Management (SM) is performed automatically by ground automation. If conflicts are detected, the ground automation issues revised 4DTs to the flight operator.
Area Navigation (RNAV)	A method of navigation that permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids, the limits of the capability of self-contained aids, or a combination of these.
Area Navigation (RNAV) Operations	Aircraft operations that provide more direct routing between the departure and arrival airports. RNAV Operations remove the requirement for a direct link between an aircraft and a navigational aid. Waypoints are developed for the aircraft to navigate by using bearing and distance information from nearby navigational aids.
Area Navigation (RNAV) Route	An ATS route established for the use of aircraft capable of employing area navigation.
Arrival/Departure Airspace	Airspace from the top of climb or descent to the airport surface. It includes only the arrival and departure corridors in current use, but extends to en-route altitudes.
Automated NextGen Tower (ANT)	A facility where sequencing services and basic airport information are provided without the use of ANSP personnel, at a service level that is enhanced compared with typical non-towered airports.
Auto-Negotiation	The interaction among two or more systems to identify a specific operational response acceptable to the parties (e.g., flight operator and ANSP) served by the automated system. The automated systems would use the known operating constraints or user preferences to identify the preferred response.

Term	Definition
Capacity	The maximum number of aircraft that can be accommodated in a given time period by the system or one of its components (throughput).
Capacity Management	The long-term and short-term management and assignment of NAS airspace and routes to meet expected demand. This includes assigning related NAS assets as well as coordinating longer term staffing plans for airspace assignments. It includes the allocation of airspace to airspace classifications based on demand, as well as the allocation of airspace and routes to ANSP personnel to manage workload.
Classic Airspace	Low-altitude airspace away from the busiest terminal areas (those not engaged in super-density operations) that accommodates mixed capability aircraft, including those under visual flight rules.
Collaborative Air Traffic Management	The collaborative process among the ANSP, flight operators, airport operators, and other stakeholders, to manage objectives for capacity management, flow contingency management, and trajectory management. Collaborative air traffic management (C-ATM) is the means by which flight operator objectives and constraints are balanced with overall NAS performance objectives.
Complexity	A description of traffic demand levels that factors large numbers of vertically transitioning aircraft, aircraft crossing paths, and aircraft speed variations.
Conflict	Any situation involving an aircraft and a hazard in which the applicable separation minima may be compromised.
Constraint	Any limitation on the implementation of an operational improvement, or a limitation on reaching the desired level of service.
Controlled Time of Arrival	The assignment and acceptance of an entry/use time for a specific NAS resource. Examples include point-in-space metering, time to be at a runway, or taxi waypoints.
Cooperative Surveillance	The determination of an aircraft’s 3D position utilizing equipment on the airframe. In comparison, non-cooperative surveillance would be the determination of an aircraft’s 3D position without the aircraft participating.
Demand	The number of aircraft requesting to use the ATM system in a given time period.
Enablers	An enabler describes the initial realization of a specific NextGen functional component needed to support one or more OIs or other Enablers. Enablers describe material components, such as communication, navigation, and surveillance systems, as well as non-material components, such as procedures, algorithms, and standards.
Enterprise Services	Any or all of the key services that are provided to all COIs throughout NextGen, and can be characterized by the net-centric infrastructure services that provide connectivity and universal access to information; and by services that provide the collection, processing, and distribution of information. This includes Shared Situational Awareness, Security Management, Safety Management, Environmental Management, and Performance Management Services.

Term	Definition
Environmental Management System	An organizational business process that consists of four phases. In the first “planning” phase of the NextGen EMS, the organization will identify environmental issues with the potential to constrain future capacity. These will be the focus of tactical, measurable objectives for which improvement initiatives can be undertaken during the second “implementation” phase. During the third “assessment” phase, the effectiveness of these initiatives is monitored and key performance metrics tracked. Monitoring data are then used to support planning at the organization itself in the fourth “review and adaptation” phase. In the NextGen EMS, monitoring data will also be reported at an enterprise level to support NextGen-wide planning.
Equivalent Visual Operations	The capability to provide aircraft with the critical information needed to maintain safe distances from other aircraft during non-visual conditions, including a capability to operate at levels associated with VFR operations on the airport surface during low-visibility conditions. The ANSP personnel delegate separation responsibility to the flight operators. This capability builds on net-enabled information access, certain aspects of performance-based services, and some elements of PNT services and layered adaptive security.
Flight Crew	The individual or group of individuals responsible for the control of an individual aircraft while it is moving on the surface or while airborne.
Flight Object	The representation of the relevant information about a particular instance of a flight. The information in a flight object includes (1) aircraft capabilities, including the level of navigation, communications, and surveillance performance (e.g., FMS capabilities); (2) aircraft flight performance parameters; (3) flight crew capabilities, including level of training received to enable special procedures; (4) 4DT profile and intent, containing the “cleared” 4DT profile plus any desired or proposed 4DTs; and (5) aircraft position information and near-term intent. Standards for the definition of a flight object are in development.
Flight Operator	The organization or person responsible for scheduling, planning, and directly operating the aircraft. Roles within the flight operator include the flight scheduler, flight planner, and flight crew and may reside with one individual or be delegated to separate individuals.
Flight Plan	A collection of data relating to a specific aircraft or formation of aircraft containing all the information necessary for tracking and producing flight progress strips used to control the flight.
Flight Planning	A series of activities preformed before a flight that includes, but is not limited to, reviewing airspace and navigation restrictions, developing the route, obtaining a weather briefing, completing a navigation log, filing a flight plan, and inspecting the aircraft.
Flight Plan Filing and Flight Data Management Services	The management of data related to a flight, from the initial filing of a proposed flight to the closing of the flight plan and the archiving of the data to support performance management analyses.

Term	Definition
Flow Contingency Management	The process that identifies potential flow problems, such as large demand capacity imbalances, congestion, a high degrees of complexity, blocked or constrained airspace, or other off-nominal conditions. It is a collaborative process between ANSP personnel and airspace users to develop flow strategies to resolve the flow problems. Examples of flow strategies include establishing routing to reduce complexity, restructuring airspace, and allocating access to airspace or runways.
Flow Corridor	A corridor is a long “tube” of airspace that encloses groups of flights flying along the same path in *one* direction. It is airspace procedurally separated from surrounding traffic and special use airspace, and it is reserved for aircraft in that group. There is a minimum distance that traffic within the corridor must maintain from the edge of the corridor (i.e., “the corridor walls have some thickness”).
Flow Strategy and Trajectory Impact Analysis Services	This capability in NextGen provides a common “what if” function to assess potential changes in planned flights, the allocation and configuration of assets, as well as other conditions (e.g., weather, security initiatives, etc.) that may affect flight operations.
Four-Dimensional Trajectory (4DT)	A 4DT represents the “centerline” of a path plus the positioning uncertainty, including waypoint. Positioning uncertainty includes lateral, longitudinal, and vertical positioning uncertainty. Some waypoints within a 4DT may be defined with controlled times of arrival (CTAs), which constrains the uncertainty for planning purposes. The required level of specificity of the 4DT will depend on the operating environment in which the flight will be flown. Associated with a 4DT is the separation zone around an aircraft and the aircraft intent information, which provides near-term information on the expected flight path.
General Aviation	All civil aviation operations other than scheduled air services and nonscheduled air transport operations for remuneration or hire.
Hazards	The objects or elements from which an aircraft can be separated. These include other aircraft, terrain, weather, wake turbulence, incompatible airspace activity, and, when the aircraft is on the ground, surface vehicles and other obstructions on the apron and maneuvering area.
High Performance (HP) Trajectory Based Operations (TBO)	In high–density or high-complexity airspace, High Performance TBO (TBO) aligns all TM functions across all time horizons based upon the aircraft’s 4DT, through use of Digital data communication. Data communication, ground-based, and airborne automation to create, exchange, and execute 4DTs are prerequisites for TBOs.
Human-Centric	The ATM system is designed around the capabilities and limitations of humans. It assigns functions to humans that are best performed by them, and it provides automation assistance when it can improve decision-making or make the humans’ tasks easier. It does not imply that humans are always in direct control.
Human Factors	The discipline concerned with the understanding of interactions among humans and other elements of a system. It applies theory, principles, data, and other scientific methods to system design to optimize human well-being and overall system performance.
Information Services	A service that provides data and information to subscribers when and where needed in a common format. Ensures questions raised by data consumers are answered correctly and consistently.

Term	Definition
Infrastructure Services	A service that provides communications connectivity to ensure information flows work reliably to support information communications and sharing functions.
Integrated Risk Management (IRM)	A process that includes prognostic tools, models, and simulations at the strategic, operational, and tactical level to support all stakeholder decision makers and managers in the grafting of cost-effective "best practices" into the design, acquisition, deployment, and operation of aviation security system assets and infrastructures. Knowledge bases concerning threats, vulnerabilities, and practices are tailored to user profiles that proactively determine need/authorization to know.
Intelligent Agents	Within the context of this operational concept, refers to a computational system that includes the following characteristics: is aware of constraints, has goals, and operates autonomously within its construct to identify information or opportunities for human action. It is customized for an area or task, is adaptive, knows the user's preferences/interests, and can operate on their behalf (e.g., by narrowing the choices available through auto-negotiation). As such, this concept's definition is consistent with commonly accepted industry standards.
Intent	Information on planned future aircraft behavior, which can be obtained from the aircraft systems (avionics). It is associated with the commanded trajectory and takes into account aircraft performance, weather, terrain, and ATM service constraints. The aircraft intent data correspond either to aircraft trajectory data that directly relate to the future aircraft trajectory as programmed inside the avionics or the aircraft control parameters as managed by the automatic flight control system. These aircraft control parameters could either be entered by the flight operator or automatically derived by the flight management system.
Layered Adaptive Security	The security system will be constructed in "layers of defense" to detect threats early and prevent them from meeting their objective while minimally affecting efficient operations. Airports and aircraft will be designed to be more resilient to attacks or incidents. Building on the "net-enabled information access" and "performance-based services" capabilities, risk assessments will begin well before each flight so that people and goods will be appropriately screened as they move from the "airport" curb to the aircraft, or as they support aerodrome/aircraft operations. As technology matures, screening will be unobtrusive and more transparent to the individual. All people and cargo that "touch" or are carried by an aircraft will be positively identified. Responses to anomalies and incidents will be proportional to the assessed risk of the involved individuals or cargo.
Managed Airspace	An Air Navigation Service Provider provides Air Traffic Management Services; separation is delegated as appropriate to equipped aircraft.
Metroplex	A group of two or more adjacent airports whose arrival and departure operations are highly interdependent.

Term	Definition
Near-Space Airspace	Low-density, low-complexity airspace at very high altitudes that accommodates a wide range of special operations (e.g., high-speed reconnaissance aircraft, aerostats, long-endurance orbiting unmanned aircraft systems).
Net-Centricity	The realization of a globally-interconnected network environment, including infrastructure, systems, processes, and people, that enables an enhanced information sharing approach to aviation transportation.
Net-Enabled Information (NEI)	An information network that makes information available, securable, and usable in real time to distribute decision making. Information may be pushed to known users and is available to be pulled by other users, including users perhaps not previously identified as having a need for the information.
Network Enabled Operations (NEO)	The decision support and other applications using NEI for information transfer and retrieval.
NextGen Decision Oriented Tool (NDOT)	A tool that incorporates observations, forecasts, model/algorithm data, and climatology, including surface observations and weather aloft to allow full integration of weather into traffic flow decision making.
NextGen Network Enabled Weather (NNEW)	The 4D net-centric weather information network that publishes discoverable past, current, and future weather data and information for decision makers; enabling weather situational awareness when planning and executing operations across the full spectrum of the Air Transportation System.
Non-Managed Airspace	Uncontrolled, low-altitude airspace where no ANSP services are provided, except as required to coordinate entry to a different class of airspace.
Oceanic Airspace	That airspace over the oceans of the world, considered international airspace, where oceanic separation and procedures per ICAO are applied. Responsibility for the provisions of ATC service in this airspace is delegated to various countries, based generally upon geographic proximity and the availability of the required resources.
Performance-Based Navigation	Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace. Note: Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability, and functionality needed for the proposed operation in the context of a particular airspace concept.
Performance-Based Operations	Use of performance capability definition versus an “equipment” basis to define the regulatory/procedural requirements to perform a given operation in a given airspace.

Term	Definition
Performance-Based Services	There are multiple service levels aligned with specified user performance thresholds to provide choices to users depending on needs, required communication, navigation and surveillance performance, environmental performance criteria, security parameters, and so forth. Services will be flexible according to the situation and consolidated needs of the users. Services vary from area to area in terms of airspace and "airport" surfaces, and they vary with time as needs dictate. Preferences are established based on user capability, equipage, training, security, and other considerations. The performance-based approach is used to analyze risks (e.g., safety, security, environment) instead of "equipment-based" approaches. The performance-based services capability will enable a definition of service tiers and allow the government to move from equipment-based regulations to performance-based regulations.
Position, Navigation, Timing (PNT) Services	A service that enables the ability to accurately and precisely determine one's current location and orientation in relation to one's desired path and position; apply corrections to course, orientation, and speed to attain the desired position; and to obtain accurate and precise time anywhere on the globe, within user-defined timeliness parameters.
Required Navigation Performance	A statement of the navigational performance necessary for operation within a defined airspace. The following terms are commonly associated with RNP: (a.) - Required Navigation Performance Level or Type (RNP-X). A value, in nautical miles (NM), from the intended horizontal position within which an aircraft would be at least 95-percent of the total flying time. (b.) - Required Navigation Performance (RNP) Airspace. A generic term designating airspace, route(s), leg(s), operation(s), or procedure(s) where minimum required navigational performance (RNP) have been established. (c.) - Actual Navigation Performance (ANP). A measure of the current estimated navigational performance. Also referred to as Estimated Position Error (EPE). (d.) Estimated Position Error (EPE) - A measure of the current estimated navigational performance. Also referred to as Actual Navigation Performance (ANP). (e.) - Lateral Navigation (LNAV). A function of area navigation (RNAV) equipment which calculates, displays, and provides lateral guidance to a profile or path. (f.) - Vertical Navigation (VNAV) - A function of area navigation (RNAV) equipment which calculates, displays, and provides vertical guidance to a profile or path.
Required Navigation Performance Level or Type (RNP-X)	A value, in nautical miles (NM), from the intended horizontal position within which an aircraft would be at least 95 percent of the total flying time.
Route	A 3D path through space with no time component. Unlike corridors, aircraft can cross routes as operational need requires, with proper separation provided to all aircraft.
Safety Assurance	The independent oversight function that tests, evaluates, and certifies, as necessary, products and processes to ensure that they are safe for the public and stakeholders.
Safety Culture	The product of individual and group values, attitudes, competencies, and patterns of behaviors that determine the commitment to, and the style and proficiency of, an organization's health and safety programs.

Term	Definition
Safety Management System (SMS)	The process that provides a systematic method for managing safety. The four components of an SMS are policy, architecture, assurance, and safety promotion.
Safety Risk Management (SRM)	The set of processes and practices by which a concept and its operation are designed and made to be safe.
Self Separation Airspace	That airspace where aircraft self-separation enables maximum user flexibility in exchange for high-capability equipage of the aircraft.
Separation Management	The function of ensuring aircraft or vehicles maintain safe separation minima from other aircraft or vehicles, protected airspace, terrain, weather, or other hazards. The function may be performed by ANSP personnel, the flight operator, and/or automation.
Separation Minima	The minimum longitudinal, lateral, or vertical distances by which aircraft are spaced through the application of air traffic control procedures.
Service Oriented Architecture (SOA)	A design for linking computational resources (principally, applications and data) on demand to achieve the desired results for service consumers (which can be end users or other services). The Organization for the Advancement of Structured Information Standards (OASIS) defines SOA as the following: *A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with, and use capabilities to produce desired effects consistent with measurable preconditions and expectations.*
Shared Situational Awareness (SSA)	The sharing of information among the processes and applications that constitute the information services function to the stakeholders in the system.
Situational Awareness	A service provider or operator’s ability to identify, process, and comprehend important information about what is happening with regard to the operation. Airborne traffic situational awareness is an aspect of overall situational awareness for the flight crew of an aircraft operating in proximity to other aircraft.
Special Activity Airspace (SAA)	Any airspace with defined dimensions within the National Airspace System wherein limitations may be imposed upon aircraft operations. This airspace may be restricted areas, prohibited areas, military operations areas, air ATC assigned airspace, and any other designated airspace areas. The dimensions of this airspace are programmed into URET and can be designated as either active or inactive by screen entry. Aircraft trajectories are constantly tested against the dimensions of active areas and alerts issued to the applicable sectors when violations are predicted.
Staffed NextGen Tower (SNT)	A facility where surface and tower services are provided by ANSP personnel, providing other-than-direct visual observation, who may or may not be located at the facility.
Stakeholders	All entities that are have a vested interest in ensuring the safest and most efficient operation of the NextGen. Through performance metrics analysis and research, these entities see that the proper training is coordinated and provided to the appropriate COIs, and that other enterprise needs are met.
Super-Density Flexible Airspace	The specific airspace configurations or routes chosen in near-real time to provide flexibility and maximize arrival and departure throughput. It is smaller than or lies within super-density protected airspace.

Term	Definition
Super-Density Protected Airspace	The charted airspace protecting super-density terminals that is somewhat larger than the actual airspace used operationally. Statically defined for low-capability aircraft that do not have access to real-time updates of airspace definition.
Surveillance Services	This service integrates cooperative and non-cooperative airport surface and airspace surveillance systems, fostering real-time air and airport situational awareness and enhancing safety and security.
Trajectory Management	The function of fine-tuning trajectories as required by the airspace plan or an active flow contingency management initiative to minimize pairwise contention and ensure efficient individual trajectories within a flow.
Trajectory-Based Operations	The use of 4D trajectories as the basis for planning and executing all flight operations supported by the air navigation service provider.
Transition Airspace	Airspace that allows aircraft to transition from one classification of airspace to another while maintaining separation from other airspace and aircraft entering and exiting adjacent airspace.
Unmanned Aircraft System	In its most basic sense, a UAS is any aircraft that can be flow without a human on board. Unmanned Aircraft Systems (UAS) is a preferred term by RTCA, FAA, and DoD. UAS includes: Aircraft, Aircraft Control Station, Command & Control Links, and autonomous, semi-autonomous, or remotely operated vehicles. Other commonly used terms include Unmanned Aerial Vehicle (UAV), Remotely Piloted Aircraft (ROA), Remotely Piloted Vehicles (RPV), and Drone/Model/RC Aircraft.
Virtual Tower	A facility that provides surface and tower services without the requirement for ANSP personnel providing direct visual observation. Virtual towers may be automated or staffed.
Weather Information Services	A common service providing the following generic capabilities: sensor configuration, observation, forecast, and history.